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Coral Coloration and Incident Light
Super Corals - *Montipora undata*
Large Angels in the Home Aquarium
Fish Husbandry Online Course

photographs by Pavaphon Supanantananont and Michael G. Moye

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Chaetodontoplus conspicillatus (main), *Pygoplites diacanthus* (inset). Photographs by Pavaphon Supanantananont (main) and Michael G. Moye (inset).

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ADVANCED AQUARIST'S ONLINE MAGAZINE

Table of Contents

Volume VII, Issue III March 2008

EDITORIAL

March 2008 4

By Terry Siegel

Terry highlights his recent visit to Thailand.

FEATURE ARTICLE

Coral Coloration and Incident Light: A Photographic Essay 5

By Ken S. Feldman, Sanjay Joshi, Lauren F. Vernese, Elizabeth A. Huber, Kelly M. Maers, Matthew R. Test

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FEATURE ARTICLE

Super Corals - *Montipora undata* 18

By Dana Riddle

This coral will grow very quickly when conditions are correct. Specimens can double in size in just a few months.

FEATURED AQUARIUM

Greg Timms' 130 Gallon Reef 23

By Greg Timms

This month Greg shares the evolution of his 130 gallon reef aquarium with us.

BREEDER'S NET

Amazing Artemia! 33

By Suzy Q Applegarth

I have found it possible (actually very easy) to have a continuous culture of brine shrimp.

REEFKEEPING EVENTS

What's Happening in Your Area? 35

By Advanced Aquarist Readers

Check to see if an event is happening in your area!

AQUARIUM FISH

Large Angels in the Home Aquarium, Part II 39

By Jim McDavid

With a little thought, a little planning and a desire to provide the animals in your care with research, there is no reason why you can't keep one of these beauties healthy for 15+ years in your living room!

ONLINE COURSES

Fish Husbandry Being Offered by Marine Aquarist Courses 45

By D. Wade Lehmann

Less than a month left to sign up!

ONLINE NEWS

Reefs in the News 46

From Online News Sources

Media coverage of the state of our world's reefs, interesting information, and other marine-related news.

SPONSORS

Thank you to our Sponsors! 49

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EDITORIAL

March 2008

By Terry Siegel

Terry highlights his recent visit to Thailand.

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Less than a week ago I returned from a 3 week trip to Thailand. Although we arrived in Bangkok, often referred to as the most polluted city in the world, we headed North and visited Chiang Rai, Chiang Mai, Pai and others. Eventually, however, we flew South and first stayed on the coast in a small city called Kraby, from which we visited some small islands. The highlight for my visit to Thailand came when we took a ferry to the island called Ko Phi Phi (pronounced, ko pee pee). This island was one of the ones devastated by the tsunami of 2004. Not surprisingly, I was very interested in how the famous coral reefs in the Andaman Sea fared, at least those I could get a look at from Ko Phi Phi. Unfortunately, I didn't have an underwater camera, so I'll have to describe what I saw.

Just snorkeling off of the tip (see photo 1) at low tide brought into view some of the most beautiful coral gardens I have ever seen. Most of the growth was relatively new, recovering after the tsunami. The Acroporidae was about 1 foot to 2 feet tall and was growing on top of the Acroporidae rumble left by the 2004 tsunami. There were patches of green and blue/purple colonies of *Acropora* sp. and fields of Acropora sp that were gray but with beautiful blue growth tips. All in all, in the small area that I covered, I counted at least 20 different *Acropora* sp. There were also dark blue encrusting *Montipora* sp., or what liked like *Montipora* to me. There were *Fungia* sp. on the bottom. Almost every shape - branching, columnar, scroll, etc. -- that hermatypic corals come in I saw.

There were quite a few dead table top Acroporidae that I saw which were still standing, but nearby there were many new tabletops growing, some of which were already more than a foot across. And, much to my surprise and delight there were many *Tridacna* sp. clams: All over, embedded in dead coral there were *T. croceas*, which were electric blue. There were also *T. derasa and squamosa.* clams. The amount and beauty of this coral garden's new growth following the tsunami was surprising to me.

I also saw quite a few reef fish. There were of course parrotfish, damselfish, wrasses, and convict tangs in abundance, but what surprised me were the schools of *Chaetodon collare* butterflyfish and pairs of *C. triangulum* about. There were also quite a few pairs of Moorish idols (*Zanclus cornutus*).

Photo 2 shows the sea photographed from one of the Ko Phi Phi beaches. The darker areas in the sea are corals.

On a parting note, in Brooklyn, NY at Pratt institute there will be a major Frag Swap and mini-conference. The date is April 27th. For more information go to ManhattanReefs.com's forum for a post about the conference.

Photo 1: Coral reefs of Ko Phi Phi.

Photo 2: The sea photographed from one of the Ko Phi Phi beaches.

FEATURE ARTICLE

Coral Coloration and Incident Light: A Photographic Essay

By Ken S. Feldman, Sanjay Joshi, Lauren F. Vernese, Elizabeth A. Huber, Kelly M. Maers, Matthew R. Test

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Introduction

Viewing a reef tank as "kinetic art" has sensitized many aquarists to the complex multifactoral relationships between a host of tank parameters and the color of corals, particularly small polyped scleractinians (SPS's). Nowhere does this issue arouse more debate and more passion than on the topic of light. In no small part, the evolution of aquarium lighting sources has driven the successes experienced by numerous aquarists in sustaining captive acropora, montipora, etc. This evolution has been fueled by the introduction of metal halide light sources characterized by Kelvin ratings up to 20K, and more recently by the availability of high-output fluorescent bulbs (called T5 bulbs) with a range of spectral signatures. This broad palette of lighting options has been embraced by the contemporary reefkeeping community, and spectacular tableaus of colorful SPS's have been achieved under a variety of lighting conditions. The lack of a single unique lighting solution has led to the inevitable comparisons/debate about the relative merits of 10K vs. 14K vs. 20K metal halide bulbs, inter alia, as well as much animated discussion on the related topic of metal halide vs. T5-based lighting solutions.

Discussion and debate have their place, but in the absence of hard data, it is difficult to resolve anything. It should be possible experimentally to test directly the effect of T5 vs. 10K MH vs. 20K MH lighting on a given coral's coloration. In order to gain useful information from this type of experiment, it is important to define the variables involved, identify the constant elements, and arrive at a meaningful measure of experimental output. With these thoughts as background, we set out to probe the following question:

How does the observed color of an SPS coral vary as per the type of lighting used to grow it?

The whole concept of coral coloration impinges on many different areas of science, from the molecular genetics of corals, to the physical chemistry of light absorption by pigment molecules, to optics, visual perception, and finally to camera/computer graphics. Events at each of these levels impacts on the color the viewer perceives when observing the coral or examining a photographic representation of a coral. Corals produce a multitude of colored molecules, mostly but not exclusively proteins, in response to a variety of stimuli. The relationship between stimulus and colored molecule (protein) expression is a matter of speculation at present, and the control/regulatory elements that presumably operate at the genetic level have yet to be elucidated. Hypotheses spanning the gamut from offensive functions (i.e., light gathering antennas) to defensive capabilities (i.e., sunscreens) have been discussed, and there is no decisive evidence at present to discourage any of these lines of thinking. Salih et al. generated much interest by reporting data that they interpreted as being consistent with the sunscreen hypothesis, particularly for GFP (Green Fluorescent Protein) in *Acropora palifera*, *Acropora nobilis*, *Pocillopora damicornis*, and *Goniastrea retiformis* from shallow water at the great Barrier Reef, Australia (Salih, 2000). However, this conclusion was challenged by Mazel, who did not find any support for the idea that GFP modulated in any way the quantity of light reaching the zooxanthellae of *Montastraea cavernosa* and *Montastraea faveolata* (Mazel, 2003a). Schlichter described observations consistent with the antenna hypothesis, where fluorescent proteins appear to aid in converting photosynthetically unusable incident light into wavelengths readily absorbed by the zooxanthellae's photosynthetic reaction centers (Schlichter, 1985). Finally, Fabricius recently has reported that lighter colored corals absorb less infrared radiation, which contributes to coral heating, than darker colored corals (Fabricius, 2006). This observation might be interpreted in terms of enhancing or suppressing thermal bleaching of the coral, depending upon the darkness of the color. Riddle has detailed the UV/VIS (UltraViolet/VISible) characterization of many coral coloration proteins, and his latest article is an excellent source of contemporary thinking on this topic, along with leading references (Riddle, 2007b). In addition to the coloration molecules produced by the coral itself, the symbiotic zooxanthellae, of course, contribute a golden brown color largely as a consequence of reflectance from the pigment peridinin (Hochberg, 2006).

The color of a coral that is perceived by a viewer is a combination of incident light, reflected light and re-emitted light (fluorescence) from the coral under observation. The reflected light does not interact productively with any coral molecules, and so the

coral surface acts essentially like a mirror reflecting selective wavelengths of light. Therefore, the wavelengths (colors) contained within the incident light play a dominant role in the color of this reflected light. For example, a bulb shifted toward the blue end of the spectrum (i.e., 20K) lacks a large component of red light, and so any object reflecting 20K bulb light will appear biased toward the blue end of the color spectrum by virtue of this red light deficiency. Re-emitted light (fluorescence emission) does involve a molecular-level interaction between the light particles (photons) and a receptor molecule in the coral. Coral coloration molecules are capable of absorbing light at a specific spectral range of wavelengths, and this absorption has two consequences: (1) it removes from the reflected light those absorbed wavelengths (colors), and (2) it opens the possibility of fluorescence emission. Fluorescence results from a re-emission of light from the coral coloration molecule at a longer wavelength (shifted away from the blue and toward the red end of the color spectrum). The energy drop between the absorbed photons and the emitted photons is a consequence of the loss of excited state energy via molecular vibrations, a process well studied within the discipline of physical chemistry. Thus, a given coral coloration molecule may absorb blue light but emit green light through this fluorescence mechanism. Typical fluorescent efficiencies, as defined by (fluorescent) photons emitted-per-available incident photons, range from 3% - 10% (Mazel, 2003b). Mazel and Fuchs have attempted to quantify the amount of the fluorescent component in the observed light from the strongly fluorescent corals *Agaricia* sp., *Colpophyllia natans*, *Diploria labyrinthiformis*, *Montastraea cavernosa*, *Montastraea faveolata*, and *Scolymia* sp. (Mazel, 2003). Their estimates for the fluorescent component at a 2-meter depth range from 7% - 30% depending upon the precise fluorescence efficiency and the spectral properties of the coral coloration molecule(s). There are other mechanisms by which light might interact with corals to produce wavelength-shifted emitted light, including phosphorescence and diffraction, but the contribution of these processes to coral coloration is not clear at present. Overall, the perceived coral color will depend on a blend of reflected light (incident light absent absorbed wavelengths) and fluorescence emissions, if applicable. A good discussion of light and color can be found in the series of articles in Reefkeeping entitled "Facts of Light" (Joshi, 2006); see also Fenit (Fenit, 2005).

Color rendition by electronic devices is a complicated topic well outside the scope of this article. It is important to recognize, however, that all color rendition schemes involve compromises between the "true" color of an object and the "calculated" color depicted, whether by a camera, computer, or display device. In fact, software processing of an object's color through multiple devices may lead to even greater deviations from true color. Some details of the color processing procedure used with the images in this article, and color correction using the Gretag-MacBeth color checker technique employed herein, are provided below. A good starting point for further reading can be found in: http://www.cambridgeincolour.com/tutorials.htm.

The idea that the wavelength (color) of the light under which a coral has grown can influence some characteristic of the coral is not new. Kinzie and later Schlacher both have probed specific hypotheses is this general area of coral research. Seminal studies by Kinzie assessed coral skeletal growth rates under the influence of blue, red, green, and white growth lights for both *Montipora verrucosa* and *Pocillopora damicornis* (Kinzie, 1984). They concluded that these corals grew fastest under blue light, followed closely by white light, then green light, and finally the slowest growth was observed under red light. They followed up this study by measuring photosynthesis rates of *Montipora verrucosa* under these same lighting conditions (Kinzie, 1987). Once again, the highest photosynthesis rates were achieved under blue light; slightly lower but similar rates were observed for corals grown under both white light and green light, followed distantly by photosynthesis rates under red light. More recently, Schlacher et al. examined growth rates of *Acropora solitaryensis* under 150W metal halide bulbs rated at 5.5K, 10K, 14K, and 20K color temperatures (Schlacher, 2007). After 3 months of grow-out, the overall growth rates under the different bulbs were quite distinct: 6.2 mg/day at 5.5K, 4.9 mg/day at 10K, 8.5 mg/day at 14K, and 10.9 mg/day at 20K. Thus, the bulbs delivering the highest proportion of blue light (20K and 14K) promoted the highest growth rates. One concern clouds the interpretation of these results; the authors positioned all of the bulbs at the same height above the corals, leading to significant differences in the measured Photosynthetic Photon Flux Density (PPFD) delivered to the coral from each of these lamps. For example, the PPFD of the 20K lamp at the 400-450 nm spectral range of chlorophyll absorption is about 7.5 times greater than the PPFD of the 5.5K lamp at this same spectral range. The significance of these photon quantity differences on growth rate, independent of overall bulb "color", remains to be determined. The relationship between incident light color and consequent coral coloration, the topic of this essay, was considered by Riddle (Riddle, 2003). Using a brown *Pocillopora meandrina* as a test case, coral coloration was visually assayed after exposure of this SPS to focused light from either blue, red, green, yellow, or ultraviolet LED's over a period of greater than 7 weeks. The coral section irradiated by the blue LED turned from brown to pink, whereas the other colored lights either had no effect, or promoted coral bleaching. This limited investigation led to some intriguing speculation about the connection between growth light and coral color, and it sets the stage for the more extensive studies described below.

Experimental Design

The experiment was designed as follows: Three 10-gallon tanks were set up to hold coral fragments on eggcrate. These tanks were connected in series along with an Eheim canister filter containing live rock. The Eheim filter provides the motive force to circulate water among the three tanks, at a rate of approximately 1 turnover of the 30-gallon system volume every 3 hrs. A Phosban reactor charged with granular activated carbon (GAC) and phosban was installed for water purification. The GAC/phosban was changed every 3 weeks. A Remora skimmer completed the water purification apparatus, and an Ebo Jagger heater and Tunze osmolator held the system temperature and the system water level, respectively, constant. For circulation, each tank was equipped with a Maxijet 1200 feeding a spray bar set just under the waterline. Livestock consisted of nothing more than a few turbo and astrea snails and a peppermint shrimp, per tank. This setup equalized all of the other parameters among the three tanks, such as water quality, water temperature, water flow, salt, trace elements, etc., and isolated the light source as the only variable affecting coral coloration.

Weekly additions of alkalinity (Two Little Fishes solution B) and calcium ($CaCl_2 \cdot 2H_2O$) were employed to maintain the levels of the former at 2.4-2.9 meq/L and the later at 350 - 400 ppm.

Magnesium ($MgCl_2 \bullet 6H_2O$ + $MgSO_4 \bullet 7H_2O$) was added occasionally as needed to maintain the Mg level at 1250 - 1300 ppm. A 5-gallon water change was conducted weekly, and the tanks were fed cyclopeeze, oyster eggs and Salifert Amino Acids on a weekly basis as well.

Three approximately equal sized 0.25 - 0.5 inch frags from 6 different montipora and 5 different acropora parent colonies were cut, glued onto Aragacrete frag plugs, and placed on the eggcrate in each tank. By this protocol, each tank had one frag from each unique coral specimen. The frags from each parent colony were placed in the same locations in each of the tanks so the frags from each unique coral should experience the same, or at least very similar, light exposure and water flow. Above one tank was placed a 20K 175W XM single-ended metal halide bulb; a second tank was illuminated with a 10K 175W XM single-ended metal halide bulb, and the third tank was topped with a Tek Light fixture featuring 4 x 24W T5 bulbs (2 x 24W Aquasun VHO's in the exterior positions, 1 JALLI 10000K, and 1 AB actinic blue in the interior positions). The MH bulbs were situated in Spider reflectors, and small muffin fans were used to cool the tanks. No UV shielding was positioned between the bulbs and the tank. Note that T5 (fluorescent) bulbs do not produce significant light in the UV-A region of the spectrum (Riddle, 2007a). Likewise, the single-ended MH bulbs used in this experiment have adequate shielding in the UV-A region as a consequence of their borosilicate glass housings. In contrast, many double-ended MH bulbs do produce significant quantities of UV-A light, but the effects of this higher energy light on coral coloration are beyond the scope of these experiments. The tanks were separated by opaque white posterboard to prevent cross-contamination of light sources. With this arrangement, the tank temperature fluctuated from 76 ^{o}F (lights off) to 80 ^{o}F (lights on) over the course of 24 hours; the irradiation period lasted 8 hours/day. The height of each of the lights was adjusted to provide a constant amount of PAR at the coral level, measured by an Apogee Quantum Meter; the initial height settings of the lights delivered about 140 - 160 mE/m^2 of light intensity, but unsatisfactory coloration in this nutrient poor environment prompted the elevation of these bulbs so that the PAR readings at the corals were about 80 - 100 mE/m^2. These readings were taken at the center of the tanks, directly under the MH or T5 bulbs. Therefore, not every coral received the same amount of light, as the intensity drops off as distance from the center increases. Nevertheless, identical placement of each type of coral in the three tanks ensured, at the very least, that the light intensity for each type of coral was approximately equal between the two MH tanks, with some uncertainty in the amount of intensity variance between the MH tanks and the T5 tank. Note that this approach normalizes the PPFD, in contrast to the Schlacher experiment. The corals were grown under these conditions for 14 months. All bulbs were replaced after 12 months of continuous use. The experimental setup is illustrated in Figure 1.

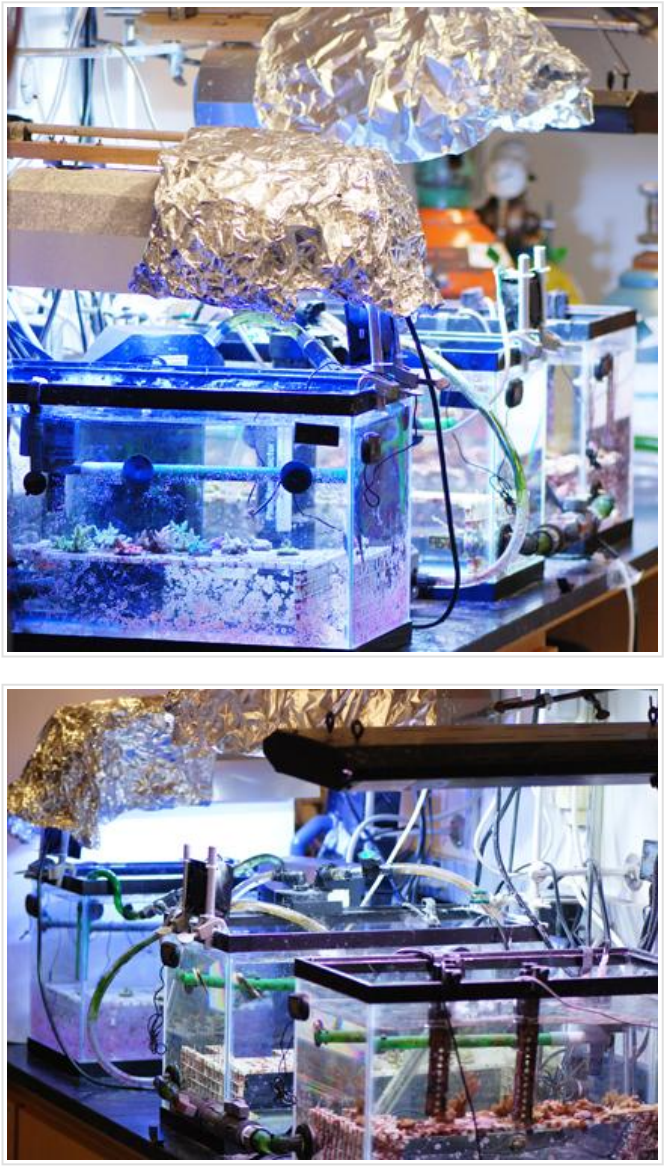

Figure 1. Left-hand view (top) and right-hand view (bottom) of three interconnected tanks for coral frag growout; the left tank is irradiated at 20K, the middle tank at 10K, and the right tank is under T5 lighting. The opaque dividers that separated the tanks were removed for these photographs.

The corals colored up and grew at appreciable rates under this experimental regimen. Photography was used to provide a visual comparison of the frag coloration from each of the tanks. A Nikon D80 camera equipped with a 105 mm Macro lens was mounted on a tripod for the photography. These pictures were taken in RAW mode through the (cleaned) front glass of the tanks, without flash. Thus, the tank lighting itself provided the only illumination for the photographs. In order to ensure that accurate colors are portrayed, color correction via white balancing was employed in the photograph workup. A Gretag-MacBeth color checker was used to regularize the white balance setting (details are given below). In addition, the computer monitor (Apple MacBook Pro) used to perform these color corrections was color calibrated using the native color calibration software provided. The corals were allowed to grow out over the course of 14 months. At that time, their colors appeared to have stabilized, and there was visible and often substantial new growth in each of the frags. At that point in time, the coral frags were photographed, and these photographs are presented below.

RESULTS

WHITE BALANCING VIA THE GRETAG-MACBETH COLOR CHECKER

The Gretag-MacBeth color checker illustrated in Fig. 2 is the standard used for white balancing in the photography industry. As an illustration of the methodology, Fig. 2 (left) shows the color checker photographed in sunlight using the automatic white balancing function of the Nikon D80 camera. Fig. 2 (middle) captures the same checker, illuminated by sunlight, taken in RAW mode. Fig. 2 (right) demonstrates how Adobe Photoshop (CS3) can be used to "correct" the color of the 2 (middle) photograph by adjusting the color scheme. Since these photographs were taken under a light source for which the camera's software is optimized, there is little difference between Fig. 2 (left) and Fig. 2 (right). In fact, the color squares of the Gretag-Macbeth color checker have standard hue values accepted by the photography profession, and so the degree of color "accuracy" can be quantified. Both the Gretag-MacBeth color scheme and the color settings used by Adobe Photoshop3 adhere to the sRGB scale. Each color utilized by Photoshop (or displayed in the color checker) is composed of a mixture of red, green, and blue primary colors ranging in intensity from 0 (= black) to 255 (= white). The scale is set up such that if RGB = 0/0/0, the displayed color is black, and if RGB = 255/255/255, the displayed color is white. If all three RGB intensity values are equal, the result is a shade of gray. The official color "red", as an example, is composed of a red intensity of 175, a green intensity of 54, and a blue intensity of 60 (Table 1, line 1, column 2), whereas yellow (not a primary color) is more of a blend: 231/199/31 (Table 1, line 5, column 2). For photographs 2 (left) - 2 (right), values spanning a representative suite of colors are shown in Table 1. Whereas there is some variance between the official hue designations and the processed colors, these differences are rather minor and almost imperceptible to the human eye.

Unlike photography under sunlight, pictures taken under high-Kelvin tank lighting conditions present significant challenges for most cameras, as the photo processing software is not designed to handle such blue-biased lighting. This problem has been discussed extensively elsewhere (Rothschild, 2005). While white balancing in Photoshop via the color checker may be an imperfect solution, there appears to be no better option for eliminating the biases of color adjustment. Fig. 3 illustrates the outcome of white balancing in the most difficult case, 20K incident light. Similarly, Figs. 4 and 5 present the optimized color corrections realized under the 10K bulb and the T5 bulbs, respectively. A quantitative representation of these corrections is displayed in Table 2. It is evident that the corrected colors differ from the accepted colors by greater margins with the aquarium lighting, especially under the 20K bulbs, than with sunlight as the light source.

One approach to quantifying the differences between the corrected color values and the true values is shown in Fig. 6. In these graphs, the accepted intensity values for all hues (and colors within hues) listed in Table 2 were plotted on the X-axis against the corrected values on the Y-axis. In the ideal case of perfect color correction, the correlation lines between these two sets of data will have a slope of 1.00, and the scatter of the data, as represented by the r^2 value, would be negligible (r^2 approaches 1.00). In practice, these criteria for success are met best by the T5 color correction, and least by the 20K color correction. The 20K color correction in general tends to significantly underestimate the red intensities overall (slope = 0.77), but that underrepresentation is partially compensated by an enhancement of the green channel (slope = 1.23). Simply increasing the red intensity and/or decreasing the green intensity in the color correction process leads to obviously false color images. The difficulty with color correcting the light from the 20K lamps may be due to the fact that

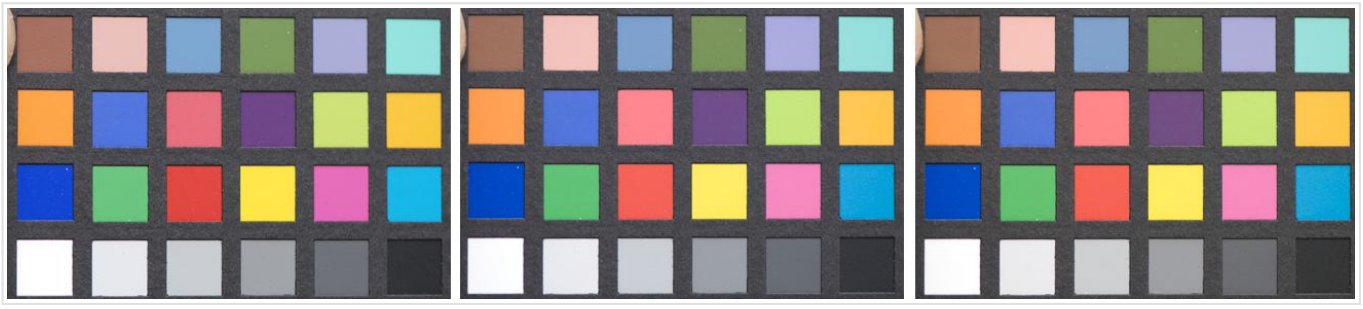

Figure 2. The Gretag-MacBeth color checker white balance correction for photography under sunlight. Left: the camera-auto white balanced file. Middle: the uncorrected RAW file. Right: the corrected colors in the processed picture file.

Table 1. Color (hue) comparisons via the Gretag-MacBeth color checker. The data are reported as Red/Green/Blue values.

color	accepted hue	Fig. 2 (left) hue	Fig. 2 (middle) hue	Fig. 2 (right) hue
red	175/54/60	225/74/67	216/99/89	218/100/86
blue	56/61/150	18/71/213	4/74/195	14/77/190
green	70/148/73	109/198/130	133/193/121	136/194/118
purple	94/60/108	110/69/135	104/79/136	107/80/131
yellow	231/199/31	255/230/76	255/236/115	255/236/107
white	243/243/242	255/255/255	252/253/255	253/253/253
medium gray	160/160/160	161/164/171	157/160/167	160/161/163
black	52/52/52	50/51/55	56/57/61	61/63/62

these lamps are not true 20K lamps and lie far off the black body curve used to determine the color temperature of the bulbs (Joshi 2006) Nevertheless, these corrections are the best available, and they will be applied to the coral photographs presented below.

Figure 3. The Gretag-MacBeth color checker white balance correction for photography under 20K MH 175W XM bulbs. Left: the uncorrected RAW file. Right: the corrected colors in the processed picture file.

Figure 4. The Gretag-MacBeth color checker white balance correction for photography under 10K MH 175W XM bulbs. Left: the uncorrected RAW file. Right: the corrected colors in the processed picture file.

Figure 5. The Gretag-MacBeth color checker white balance correction for photography under T5 24W bulbs. Left: the uncorrected RAW file. Right: the corrected colors in the processed picture file.

Acropora photographs

Five acropora species were fragged and grown out as described in the Experimental section. The origins of the coral are indicated, and all five corals are given a provisional species identification. This identification should be considered tentative, and typically was provided by the vendor. Correct species identification would be greatly appreciated and should be forwarded to the authors. In each case, a photograph of the parent colony in one of the author's aquariums is provided. Four of these five parent colony photos were taken with a Canon PowerShot S500 point-and-shoot camera with automatic white balancing, whereas the fifth (*A. carduus*) was captured with a Nikon D80, again with automatic white balancing. Both growth light and photography light for these parent colonies was provided by 10K 400W XM bulbs.

1. *A. carduus* (Fig. 7)

An aquacultured "baby blue bottlebrush" was purchased from Atlantis Aquarium and tentatively identified as *A. carduus* by one of the authors. Under 10K 400W XM lighting, the mother colony remained largely beige in color, with a slight hint of blue when viewed from the top. When viewed under either 10K or T5 lighting, the frags of this coral grown under any of the experimental lights appeared uniformly beige, much like the parent colony. However, when viewed under 20K lighting, the frag grown under 20K irradiation, uniquely, did appear to have a slight greenish tinge, especially near the base growth area. The frags grown under either 10K or T5 lighting did not display this faint color when viewed under 20K light. Thus, this observation is consistent with a scenario wherein 20K growth light actually induces the production of a green coral coloration molecule, but that same pigment is not induced when the coral is grown under either 10K or T5 lighting.

2. *Acropora insignus* (Fig. 8)

This aquacultured coral was purchased from Pacific East Aquaculture as a small colony. It appeared to be light blue with darker blue corallites when grown under 10K lighting. In the experimental tanks, it never achieved this blue color, but it did take on a greenish cast. All frags under a given photography lighting appeared to be colored identically. When viewed under either T5 or 10K lighting, the green color was barely perceptible. However, when viewed under 20K lighting, all frags, irrespective of the specific growth light, displayed a bright green pigment (GFP??). Thus, this coral appears to be an example of a case where the higher temperature lighting is necessary to bring out the striking green color, but the coral coloration molecule that is responsible for this hue is present under all three growth lights.

3. *Acropora hoeksemai* (Fig. 9)

This aquacultured *Acropora hoeksemai* was purchased from Atlantis Aquarium. It exhibited the typical blue-purple coloration seen in many hoeksemai specimens imported over the past several years, although the parent colony picture below does not do it justice. In the frag propagation tanks, this rich blue-purple color was never duplicated under any of the lighting conditions. In addition, the incident light frequency had no demonstrable effect on the coral's coloration. All three frags photographed under 20K light exhibited a vibrant greenish-yellow tint. Similarly, each frag set under either 10K or T5 lighting appeared identical, and furthermore, there was little difference between the hoeksemai frags' color when viewed under either of these light sources. In these 10K- and T5-illuminated photographs, the coral frags appeared to be a uniform golden-brown with a hint of green tint. Thus, the coral coloration molecules of this species are present/induced under all of the three lighting regimens. However, the

Table 2. The result of color (hue) correction, via the Gretag-MacBeth color checker, of the 20K, 10K, and T5 bulbs. The data are reported as Red/Green/Blue values.

color	accepted hue	20K hue (Fig. 3)	10K hue (Fig. 4)	T5 hue (Fig. 5)
Red	175/54/60	171/85/94	190/70/79	188/84/59
blue	56/61/150	117/0/237	85/64/180	53/33/157
green	70/148/73	119/190/127	132/180/99	95/168/63
purple	94/60/108	117/5/178	109/75/127	98/56/120
yellow	231/199/31	233/232/106	245/224/110	242/226/43
white	243/243/242	229/238/255	246/246/246	237/237/237
medium gray	160/160/160	180/173/230	187/187/187	178/178/180
black	52/52/52	49/43/79	52/52/52	45/45/45

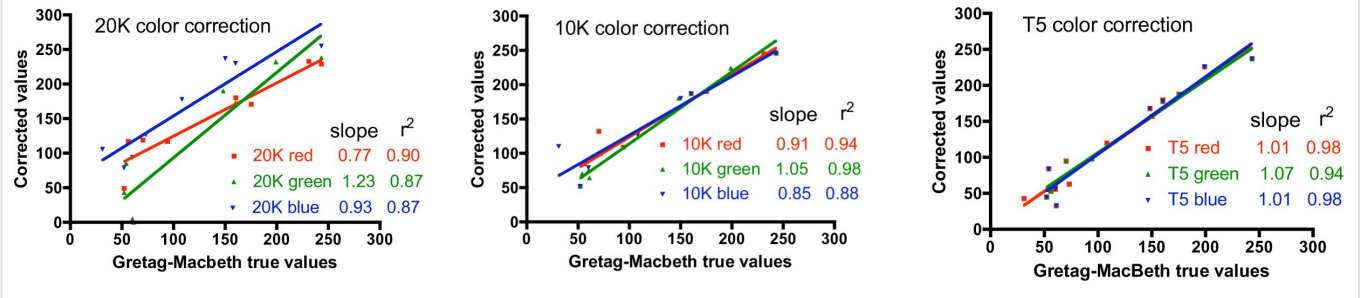

Figure 6. Graphical representation of the fidelity of the Gretag-MacBeth color checker-based corrections for the three different light sources, using the data for the colors listed in Table 2.

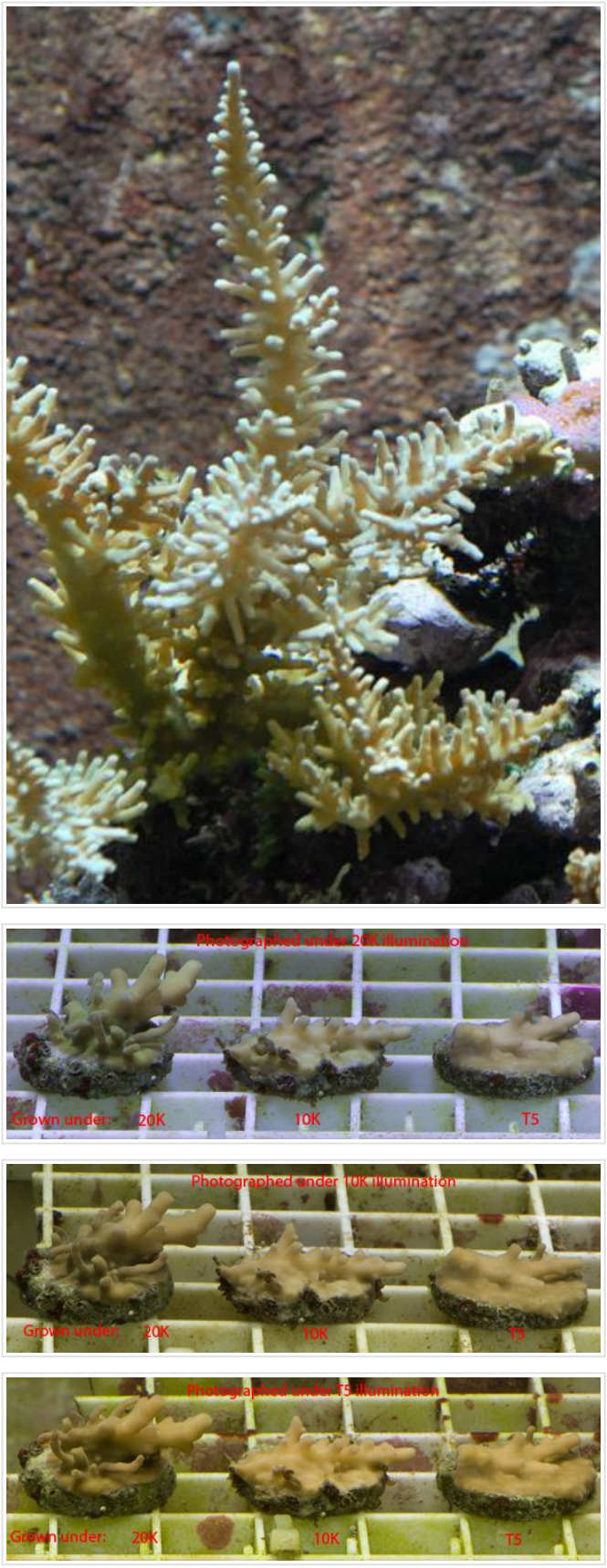
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 7. Acropora carduus: Parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

viewing light has a profound influence on the perceived color, and 20K lighting clearly provides the most captivating colors.

4. *Acropora sarmentosa* (Fig. 10)

This *Acropora sarmentosa* was purchased as a wild colony from Reefer Madness. The parent colony photograph shown below was taken just after purchase, and the colors are somewhat muted from the shipping ordeal. Upon fragging and grow-out in the propagation tanks, the coloration story with this species is similar to that described above for the *A. hoeksemai*. There is no visual evidence that growth light frequency has any influence on the coral's coloration. The frags appeared to be identically colored under a given photography lighting scheme, and it is only the viewing light that matters in any material way. Once again,

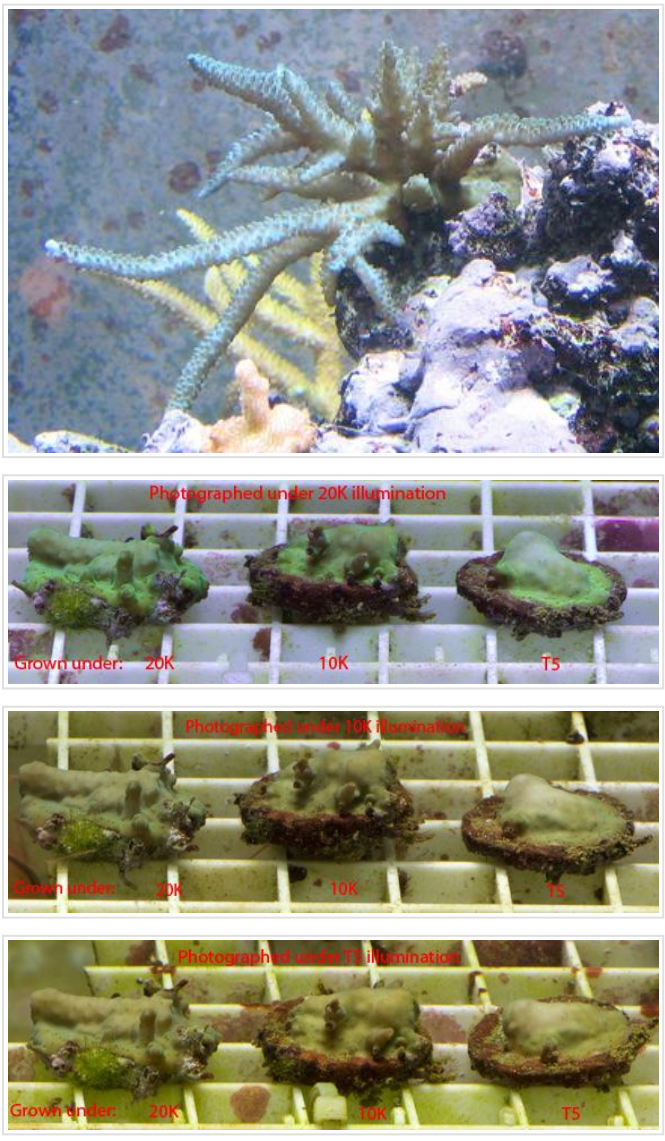
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 8. Acropora insignus: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

the 20K lighting scheme provided specimens with the most pronounced and vibrant colors. In this case, the full richness of the green is apparent. As these frags grew out further, the characteristic pink tips of the sarmentosa appeared as well (not shown). The specimens photographed under both 10K and T5 lighting all appeared identical, with just a sheen of the green color observed under the 20K lighting. Once again, viewing lighting, and not growth lighting, makes the difference.

Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 9. Acropora hoeksemai: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

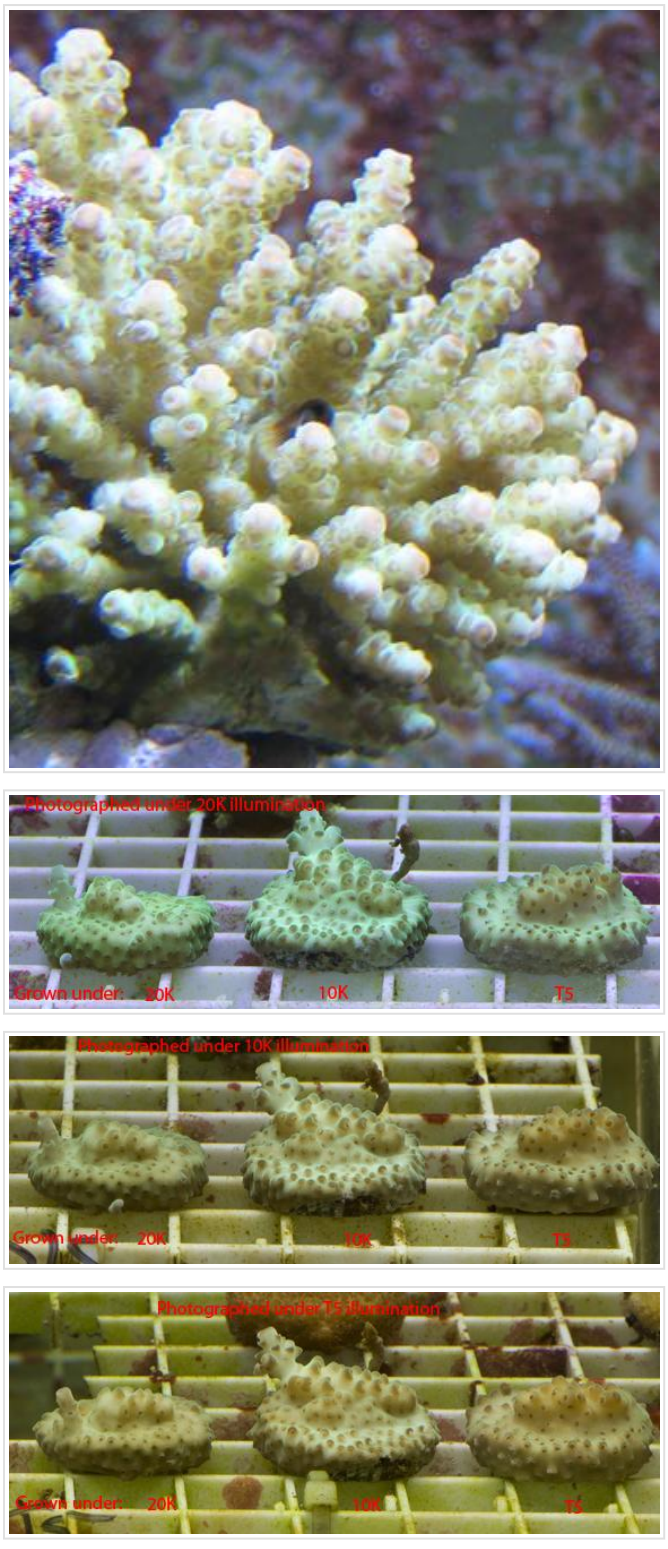
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 10. Acropora sarmentosa: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

5. *Acropora millepora* (Fig. 11)

The aquacultured *Acropora millepora* recruited for this study was purchased from Phishy Business. Its color was not stable in its home tank, and over an approximately 1.5 year period it went through several color changes. It initially arrived as a "bubblegum" pink colony, but that color faded to peach as the coral grew. In addition, the new growth of the encrusting base, but not the growth tips, was green! Eventually, the overall peach color morphed into a rust red-brown. The environmental stimuli that drove these changes are unknown; reaction with molecular oxygen ("oxidation") has been cited in pigment color shifts (called "kindling"), and it is possible that slow protein oxidation plays a role in these shifts (Riddle, 2007b). The photograph of the parent colony shown below depicts this coral in its "peach" phase. True to its behavior in its home tank, the frags grown out under the different illumination conditions did shown color sensitivity to the growth light frequency. When viewed under 20K lighting, the frag grown out under 20K illumination had a peach colored body, green growth tips, and a distinct purple cast to the growth edge of its base. In contrast, the 10K-growth/20K-photographed frag expressed the peach body color/green growth rim seen in the parent colony during one of its early phases. The frag grown out under T5 lighting and visualized under 20K lighting was different again: a green body with a purple growth rim. The color variations observed under both 10K and T5 lighting were much less dramatic. Under 10K photographic illumination, all corals appeared as mainly beige-peach, but the one frag grown under 10K lighting had unique and distinct green growth areas at its burgeoning tips and the rim of its base. When viewed under T5 lighting, all frags appeared similarly beige-peach, and the green growth rim of the 10K-grown specimen was barely detectable. As with the other acropora species, viewing this millepora under 20K lighting brings out more dramatic colors. Apart from this obvious conclusion, this coral exhibited the most pronounced variation in color as a function of growth light among all of the coral species examined. The 20K photography results suggest that perhaps three coral coloration molecules are involved: peach, green, and purple. Alternatively, the purple color might be attributable to the superposition of green and peach coloration molecules, and not to a distinct third pigment. The frag grown out under 20K lighting appears to express all three colors in different growth zones. The frag grown out under 10K lighting appears to lack substantial amounts of the purple pigment, or alternatively, it lacks spatial overlap between the peach and green pigments. The frag grown out under T5 lighting appears to lack substantial areas containing only the peach colored pigment. Thus, these observations provide evidence in support of the hypothesis that different growth lights can induce the production of different coral coloration molecules, and help rationalize the color variations in the parent colony over time.

Montipora photographs

Six montipora species were fragged and grown out as described in the Experimental section. The origins of the coral are indicated, and five out of the six specimens are given a provisional species identification. This identification should be considered tentative, and typically was provided by the vendor. Correct species identification would be greatly appreciated and should be forwarded to the authors. In four out of the six examples, a photograph of the parent colony in one of the author's aquariums is provided. These parent colony photos were taken with either a Canon PowerShot S500 point-and-shoot camera with automatic white balancing (orange *M. digitata*, *M. capricornis*, *M. sp.*?) or a Nikon D80 also with automatic white balancing (*M. danae*). Both growth light and photography light for the parent colonies was provided by 10K 400W XM bulbs.

1. *M. digitata*, orange (Fig. 12)

The orange *Montipora digitata* was acquired from a 10-year old colony with multiple generations maintained by one of the authors at the Penn State Aquarium. The parent colony maintained its robust orange color with pinkish growth tips in its home aquarium over the course of many years. In the experimental tanks, however, it never regained this solid orange hue, but rather acquired a much more pink tint to the orange base color throughout. When viewed under 20K lighting, the frags grown under either 20K or T5 lighting appeared identical and largely pink throughout. Under this same lighting, the specimen grown

Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 11. Acropora millepora: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

under 10K lighting had the most noticeable orange tint, especially in the polyps. These color relationships are maintained throughout the other two viewing light schemes. Under both T5 and 10K viewing lights, the coral frags grown under both 20K and T5 lighting appeared the most pink, and were essentially indistinguishable in color. The frag grown under 10K lighting, whether viewed under either 20K or T5 lighting, maintained its decidedly orange cast with pink overtones. Thus, this coral exemplifies a case where growth light does matter - the frag grown under 10K lighting has distinctly more orange pigment than pink pigment, but viewing light does not matter - the color variation noted above is evident under all three viewing lights.

2. *M. digitata*, purple (Fig. 13)

The purple *Montipora digitata* was acquired from the Penn State Aquarium. This coral originally came from Joe Yaiullo at Atlantis Marine World, Long Island. Unlike the orange color morph discussed above, this montipora appears to be colored identically whether grown under 20K, 10K, or T5 lighting. However, there is a distinct difference in apparent coloration as a consequence of the viewing light. Only 20K lighting clearly reveals the purple coloration of this specimen, and this purple color molecule is expressed under all growth lights. With both 10K and T5 photography lighting, this coloration molecule is not dominant in the reflected (visible) light, and the coral adopts the typical brown coloration of zooxanthellae.

3. *M. spongodes*, green (Fig. 14)

The green *Montipora spongodes* was acquired from the Penn State Aquarium. The original source of this coral is no longer known. When grown out as a larger colony, it can develop light purple tips, which are just becoming evident in the pictures below. Like the purple digitata discussed above, there does not appear to be any compelling visual evidence to support the conclusion that incident growth light influences coloration. All corals appear to have the same color under a given photography (viewing) light. However, this species does display dramatic color differences when viewed under the different lighting schemes. When viewed under 20K illumination for any growth lighting, the green color is much more vivid than under either of the other two photography lights. It appears to have a fluorescent quality, and the purple of the growth tips is more pronounced. Under 10K viewing/photography light, the color of this coral, irrespective of its growth lighting, is beginning to shift from the unmistakable green of the 20K photograph to the muddy zooxanthellae-inspired brown frequently encountered by disappointed hobbyists. This trend is extended when viewed under T5 lighting, where the "browning out" of this coral is complete. Thus, these pictures provide strong impetus for use of 20K lighting to enhance the viewing color of this particular montipora species.

4. *M. capricornis* (Fig. 15)

The *Montipora capricornis* pictured in Fig. 15 was won at a frag swap raffle with the parent colony acquired from Aqua Marines. It is likely the same coral widely sold as the "Idaho grape monti". The parent colony is quite fast growing and colored lavender throughout with purple/blue polyps. The growth lighting for this coral does appear to have a slight influence on the final coloration. Specifically, the specimen grown under 20K light appears to have a uniquely ruddy, or slightly brownish, cast to it under any photography light. The samples grown out under either the 10K or T5 lights do not share this color characteristic, and they appear to be the conventional lavender color expected for this coral, when viewed under 20K, 10K or T5 lighting. Thus, this montipora species may be another example of a coral whose coloration molecule(s) can be induced selectively by the incident light source.

Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 12. Montipora digitata (orange): 20K (top), 10K (middle), T5 (bottom).

5. M. *DANAE* (FIG. 16)

This fast-growing montipora was purchased from Atlantis Aquarium under the title of "Superman monti". Common to the montiporas already discussed, this coral's coloration does not seem to be responsive to the frequency of the growth light source. As the pictures in Fig. 16 illustrate, both the lavender base and the red/orange polyps appear identical when photographed (viewed) under any of the light sources. As with the other corals, the 20K photographic illumination causes the colors to "pop" out more than the 10K or T5 examples. Clearly, the same coral coloration molecules are present under any of the lighting regimes examined.

Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 13. Montipora digitata (purple): 20K (top), 10K (middle), T5 (bottom).

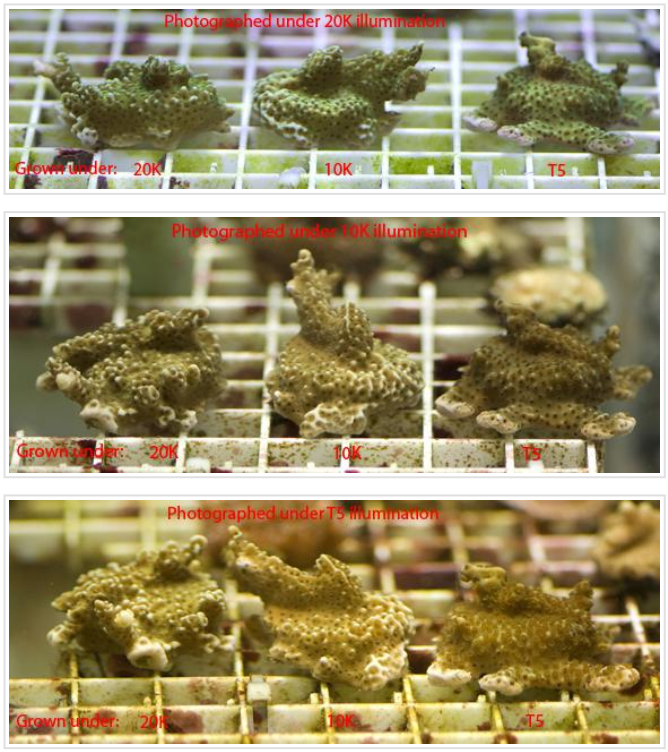
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 14. Montipora Spongodes (green): 20K (top), 10K (middle), T5 (bottom).

6. M. *SP.*, PURPLE (FIG. 17)

This slow growing montipora was the grand prize at a local frag swap raffle. It was obtained from Aqua Marines. In what is now a recurring theme, the growth lighting of this coral does not seem to have any substantial impact on its coloration, with one curious exception. The specimen grown under 10K lighting and photographed under T5 lighting is conspicuously tinted more toward the pinkish purple than the frags grown out under 20K or T5 lighting, which are more bluish purple. The significance of this observation is unclear at present. Once again, the color of this coral under 20K illumination appears to be a richer, more vibrant hue of purple than its color under 10K or T5 lighting.

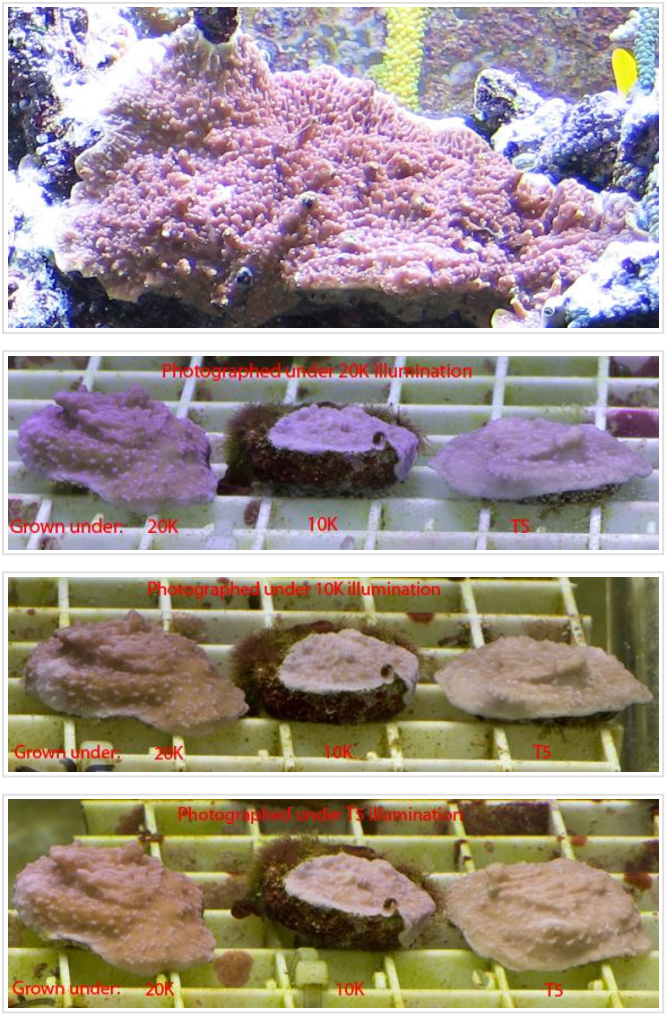
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 15. Montipora capricornis: parent colony under 10K lights, 20K (top), 10K (middle), T5 (bottom).

Conclusions

It is not possible to draw sweeping generalizations about the relationship between coral growth lighting and coral coloration based upon this limited data set of 11 SPS corals. Nevertheless, two focused conclusions are supported by these data: (1) the colors of these specific corals viewed under 20K lighting appear more vibrant compared to either 10K or T5 lighting. In addition, the coral colors appear quite similar under these latter two lighting schemes. The former observation could be due to the inability of the human eye and/or the color correction procedure to completely eliminate the dominant effect of the blue light in the 20K bulb's spectrum. (2) In some cases, the growth light does induce, uniquely, the production of specific coral coloration molecules. Whereas the first conclusion has been recognized for as long as 20K bulbs have been available, the experiments described herein suggest, for the first time, that the specific coloration molecules that define these vibrant colors are actually present in the coral even if it is grown out under lower Kelvin-rated lighting. Lighting color, of course, is just one of the possible input parameters that influences coral coloration. Water nutrient levels, light intensity water flow, salt and trace element content, oxygen concentration, temperature, pH, etc., may all contribute as well (see Riddle, 2007a for a more thorough discussion). It will be interesting to see if carefully designed experiments that isolate each of these parameters in turn can be conducted with the intent of further elaborating the specific inputs that, when summed together, lead to the stunning coral colors that aquarists find so captivating.

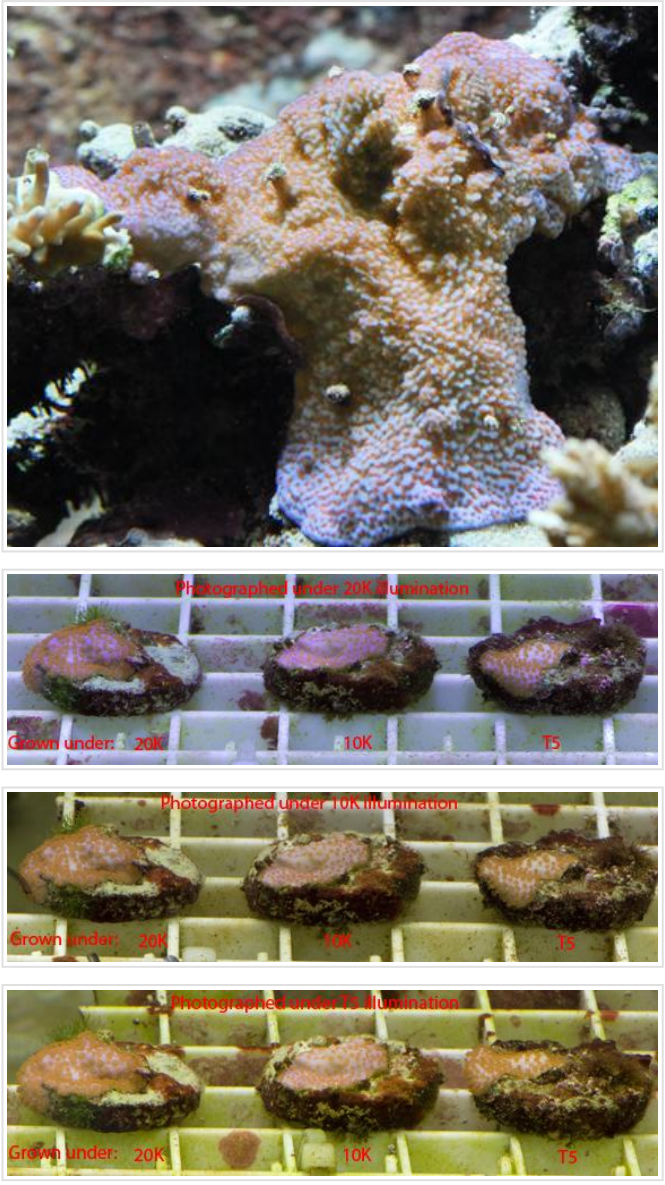
Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 16. Montipora danae: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

Photographed under 20K illumination
Grown under: 20K 10K T5
Photographed under 10K illumination
Grown under: 20K 10K T5
Photographed under T5 illumination
Grown under: 20K 10K T5

Figure 17. Montipora sp.: parent colony under 10K lighting, 20K (top), 10K (middle), T5 (bottom).

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FEATURE ARTICLE

SUPER CORALS - *MONTIPORA UNDATA*

By Dana Riddle

This coral will grow very quickly when conditions are correct. Specimens can double in size in just a few months.

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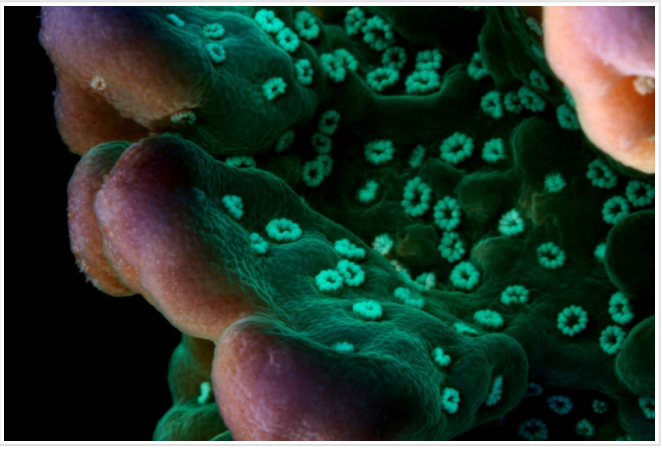
Link to original article: http://www.advancedaquarist.com/2008/3/aafeature2

This month, our discussion of Super Corals continues with a focus on an attractive stony coral *Montipora undata*. To my knowledge, this coral has no common name.

With proper conditions, this *Montipora* species can grow quickly, and its green fluorescence along with reddish-purple tips and white polyps makes it appealing.

Note that observations presented in this report are of only one specimen containing an unknown zooxanthella clade. However, there is still a lot of information available. We'll begin our discussion with the 'types' of zooxanthellae known to infect *M. undata* specimens.

- **Family:** Acroporidae
- **Genus:** *Montipora*
- **Latin Name:** *Montipora undata* (see Basis of Identification below)
- **Geographical Range:** Indian and Pacific Oceans.
- **Known Symbiont Types:** *Symbiodinium* species, Clade C1 and Clade C·.



Montipora undata contains at least one fluorescent pigment (green) and a non-fluorescent chromoprotein (purple). Polyps appear white under full spectrum lighting.

SYMBIONT TYPES

CLADE C1

Chen et al., (2005) found this clade in Taiwan *M. undata* specimens at depths of 3-5m. Clade C1 is considered a 'generalist' zooxanthellae in that it infects a large number of coral genera hosts in the Pacific as well as the Atlantic, and is distributed over a wide variety of depths. Thus, corals containing this clade could be considered highly adaptive as they can tolerate high light (but are probably best suited for lower light intensities). Evidence seems to indicate that these zooxanthellae photo-saturate at 200 - 400 µmol·m²·sec or less (or 15,000-20,000 lux; see below). Clade C1 (along with C3, C21, C3d, C1c and C45) is believed to be an ancestral type from which other clades evolved (LaJeunesse, 2004) and has been found in these corals: *Acropora cervicornis* (Baker et al., 1997), *Acropora divaricata*, *A. humilis*, *A. hyacinthus, A. longicyathus* (from the GBR; van Oppen et al., 2001), *Acropora palifera* (from Taiwan, Chen et al., 2005), *Acropora sarmentosa , A. tenuis* (GBR; Van Oppen et al., 2001), *Astreopora* (GBR, LaJeunesse et al., 2003), *Astreopora myriophthalma* (Taiwan; Chen et al., 2005), Caribbean anemones *Bartholomea* and *Condylactis* spp. (LaJeunesse et al., 2003), Great Barrier Reef 'corallimorpharia' and *Coscinaraea*, *Coscinaraea wellsi* and *Cycloseris vaughani* from Hawaii (LaJeunesse et al., 2004), *Cyphastrea* (LaJeunesse et. al., 2003), *Cyphastrea chalcidicum* (van Oppen, 2005), Atlantic and Pacific *Discosoma* spp. (LaJeunesse, 2005), *Echinophyllia orpheensis*, *Echinophyllia lamellosa* (Chen, 2005), Caribbean *Eunicea* (LaJeunesse et. al., 2003), *Euphyllia ancora*, *Euphyllia glabrescens* (Chen, 2005), *Favia* (LaJeunesse et. al., 2003), *Favia favus* and *Favites abdita* from Taiwan (Chen, 2005), *Fungia* (LaJeunesse et. al., 2003), *Fungia crassa* (van Oppen, 2005), *Galaxea*, *Goniastrea* (LaJeunesse et. al., 2003), *Goniastrea rectiformis* (Chen, 2005), *Goniopora* (LaJeunesse et. al., 2003), *Goniopora columba*, *Goniopora lobata* (Chen, 2005), *Herpolitha*, *Hydnophora* (LaJeunesse et. al., 2003), *Hydnophora excessa* (Chen, 2005), *Icilogorgia*, *Lebruna*, *Leptastrea* (LaJeunesse et. al., 2003), *Leptoria phrygia* (Chen, 2005), *Leptoseris incrustans* (LaJeunesse, 2004), *Linuche*, *Lobophytum*, *Merulina* (LaJeunesse et. al., 2003), *Merulina ampliata* (Chen, 2005), *Merulina scrabicula* (van Oppen, 2005), *Millepora* sp. ((LaJeunesse et. al., 2003), *Montipora aequituberculata* (Chen, 2005), *Montipora cactus* from Indonesia (van Oppen, 2004), *Montipora cactus, Montipora curta* from Taiwan (Chen, 2005), *Montipora confusa* (van Oppen, 2004), *Montipora digitata*, *Montipora effluorescens*, *Montipora hispida*, *Montipora* sp., *Montipora spongodes*, *Montipora undata* from Taiwan (Chen, 2005), *Mycedium* (LaJeunesse et. al., 2003), *Mycedium elephantotus* (Chen, 2005), *Pachyseris*, *Palauastrea*, Caribbean *Palythoa*, Hawaiian

Palythoa (LaJeunesse et. al., 2003), *Pavona desucata*, *Pavona frondifera*, *Pavona varians*, *Pavona venosa* (Chen, 2005), the 'bubble' coral *Plerogyra* (LaJeunesse et. al., 2003), *Plesiastrea verispora* (Chen, 2005), gorgonians *Plexaura* and *Plumigorgia* (LaJeunesse et. al., 2003), Taiwanese *Pocillopora damicornis* (Chen, 2005), *Polyphyllia*, *Porites* sp. (LaJeunesse et. al., 2003), shallow-water *Porites cylindrica*, *Porites lutea*, *Porites solida* (from Taiwan; Chen, 2006), GBR *Psammocora* (LaJeunesse et. al., 2003), *Pseudosiderastrea tayamai* (Chen, 2005), *Rhodactis*, *Rumphella*, *Sarcophyton*, Pacific *Scolymia*, *Siderastrea*, *Sinularia* (LaJeunesse et. al., 2003), *Stylocoeniella guentheri* (Chen, 2005), *Stylophora* sp. ((LaJeunesse et. al., 2003), *Stylophora pistillata* (Chen, 2005), a giant clam (*Tridacna* sp.), *Turbinaria* sp. (LaJeunesse et. al., 2003), *Turbinaria mesenteria* (Chen, 2005), and Pacific and Caribbean *Zoanthus* spp. (LaJeunesse et. al., 2003).

Clade C·

Van Oppen, 2004, reports *M. undata* specimens from Indonesia contain Clade 'C·'. Clade C· is believed to have co-evolved with *Montipora* species, but sometimes found in *Porites attenuata* and *Porites cylindrica*. Other *Montipora* species containing Clade C· include *Montipora aequituberculata*, *M. altasepta, M. angulata, M. cactus, M. capitata, M. crassituberculata, M. danae, M. delicatula, M. digitata, M. gaimardi, M. hispida, M. hoffmeisteri, M. mollis, M. peltiformis, M. spongodes, M. stellata, M. turtlensis,* and *M. verrucosa* (van Oppen et al., 2004). This clade is presently known to be distributed from Indonesia southward to the Great Barrier Reef. One has to wonder if this clade has high-fidelity to *Montipora* spp. and is one of those listed in LaJeunesse's more-or-less concurrent paper (namely Clades C17, C26a, C27, C30, C31, C31a, C31b, C32, C58 and C73). Van Oppen's IDs are based on ITS1 sequences (while LaJeunesse's - and many others'- are based on ITS2 DNA fingerprinting).

These works are important to hobbyists if we subscribe to the hypothesis that corals containing the same clade(s) zooxanthellae will have the same adaptive capacities to light intensity. As technology evolves, and more samples are studied, our knowledge will undoubtedly change about coral/symbiont relations. For the moment, this is the best information we have.

M. undata- How Much Light?

Second only to 'How much is it?' is usually 'How much light does it need?' And, the answer is 'Not much, relatively speaking.' Figure 1 shows the rate of photosynthesis of a single *M. undata* specimen under various light intensities (See 'Methods and Materials' for a description of equipment used to measure photosynthesis).

Perhaps some explanation is needed in order to understand the chart. The curved orange line demonstrates the rate of photosynthesis (rETR, for Electron Transport Rate between Photosystem II and Photosystem I) relative to light intensity (the yellow numbers at the bottom of the chart and labeled as 'PAR' - for Photosynthetically Active Radiation). A quick inspection says maximum photosynthesis occurs at PAR values of about 180-200 µmol·m²·sec (or ~9,000 - 10,000 lux). The chart also has other information - that of 'on-set of photosaturation.' The method described by Kirk (1983) is used to determine on-set of saturation. If the initial rate of photosynthesis (characterized by the left hand side of the orange line in the chart of Figure 1) was to continue in a linear fashion (the green line), its intersection with the maximum rate of photosynthesis (the red line) is the onset of photosaturation (the vertical yellow line intersect with the PAR values at the bottom - in this case, onset of saturation is in the neighborhood of 110 µmol·m²·sec (or ~5,500 lux) with full-blown photosaturation at 180-200 µmol·m²·sec (or ~ 9,000 - 10,000 lux).

Note: The specimen in the introductory photograph is maintained under one of PFO's very early LED prototypes.

Pigments

Some *Montipora undata* specimens contain at least two pigments generated by the coral animal. These include a fluorescent protein with an emission peak at ~490nm (blue-green; See Figure 2) and an unidentified non-fluorescent chromoprotein (that appears reddish-purple under full spectrum lighting. It will appear bluish under high kelvin light sources).

Interestingly, Fluorescent Pigment (FP-490) has been found in only Acroporidae corals, including *Acropora* and *Montipora* species. The corals species containing FP-490 are *Acropora digitifera* (peak excitation at 425nm - violet light; Dove et al., 2001); *Acropora millepora* (excitation at 405nm - violet light; Cox and Salih, 2005); *Acropora aspera* (fluorescent shoulders at 501 and 514nm;

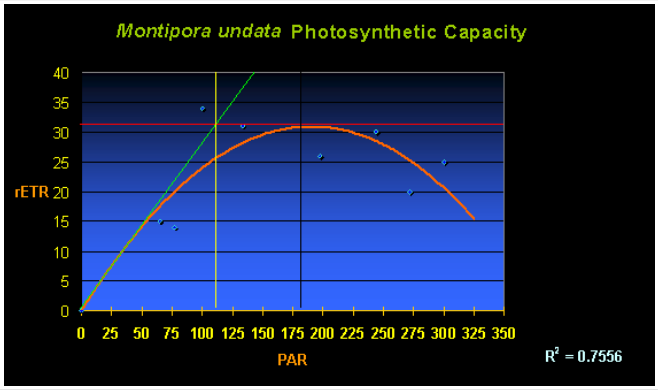


Figure 1. The rate of photosynthesis (relative Electron Transport Rate, or rETR, shown by the orange line) of a Montipora undata. In this case, maximum photosynthesis occurs at a PAR value of ~200 µmol·m²·sec. Increasing light intensity above this point is counter-productive as photoinhibition occurs.

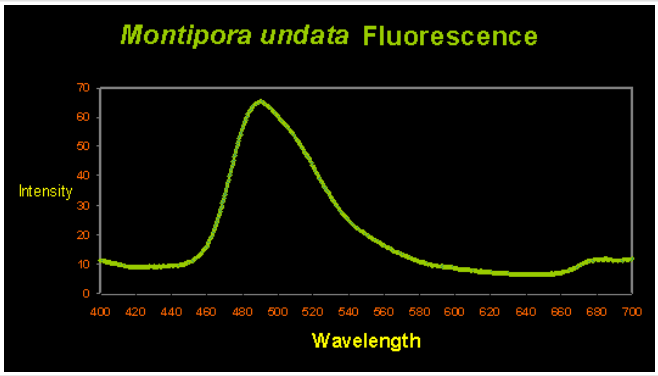


Figure 2. The blue-green fluorescent pigment has an emission peak at ~490nm.

excitation at 480nm - blue light; Papina et al., 2002); *Acropora nobilis* (excitation at 462nm - blue light; Karan et al., 2006); *Montipora monasteriata* (broad excitation at 420-450nm; Dove et al., 2001) and *Montipora undata* (this report).

In all cases, excitation wavelengths are in the violet/blue portion of the spectrum. This suggests FP-490 is best viewed under high kelvin lamps (note that UV energy also excites this fluorescent pigment and causes it to 'glow', but is not necessary). However, the purple-red non-fluorescent chromoprotein will appear dark blue. Supplemental warm light will make the purple apparent and, subjectively, more appealing.

I have not been able to identify the non-fluorescent protein's maximum reflectance or absorbance. This pigment is generated by the coral animal (and not zooxanthellae) and is usually seen in high growth areas. It is uncertain if this particular pigment eventually 'kindles' into the fluorescent green pigment (which would explain why the pigment disappears as the growth areas phase from new to old. Much work remains to be done before we understand these pigments' natures and purposes, if any).

Water Motion

This coral species does not seem especially demanding in its water flow requirements - flows measured in an aquarium found water velocity to be 'average' for a 'real' reef - 0.5 ft/sec (See 'Methods and Materials' - below - for water velocity testing protocols).

Although one half foot per second does not seem like excessive velocity (it equates to roughly 1/3 mile per hour), it does take some effort to generate this velocity in aquaria. Fortunately, the 'propeller pumps' now on the market make generating this sort of water flow quite easy.

Alkalinity and Calcium

Carbonate alkalinity is important for two reasons - it buffers against downward shifts of pH and also provides carbonates necessary for building the corallum or skeleton. Use any of the commercially available buffers to maintain an alkalinity of 175 mg/l (as $CaCO_3$) or ~3.5 meq/l. Calcium concentrations of at least 400 mg/l are recommended although values of up to 450 mg/l have been observed and seem acceptable.

Temperature

Zooxanthellae clades (a clade is something like a sub-species) found in *M. undata* are not known to be particularly heat-resistant.To avoid potential overheating of coral specimens, water temperature should not exceed 80° F when using metal halide lamps or other lamps that operate at very high temperatures (mercury vapor lamps, for instance. See Riddle, 2006 for details). This is due to absorption of heat by the coral skeleton, where it can become warmer than ambient water temperature.

Comments

This coral will grow very quickly when conditions are correct. Specimens can double in size in just a few months.

Fragmentation of this coral is easy. It can be accomplished with a Dremel tool with 'cut-off' blades or with a 'wire cutter' pliers (preferably stainless steel).

Mahalo to Steve Ruddy with Coral Reef Ecosystems (www.coralreefecosystem.com) for his invaluable assistance in preparation of this article.

Basis of Identification

Veron's Coral ID (2002) software was used for identification with 30 data points entered.

The ocean realm entered was Indo-Pacific. The exact collection point is unknown, so two likely locations were entered:

If the coral was collected from the Central Indo-Pacific (including the Philippines, Malaysia, Indonesia and the Solomon Islands), choices are *M. undata*, *M. danae* and *M. confusa* (with the software's 'Best Bet' Option choosing *M. undata*).

If the coral was collected from the oceanic west Pacific (including the Palau, Vanuatu, Fiji, and the Marshall Islands), the software's 'Best Bet' Option chose *M. undata*).

These are the other data points used for identification (based on microscopic examination of the skeleton and inspection of enlarged photographs of living animals):

- Colonial coral
- Attached to substrate (as opposed to free-living)
- Growth form is encrusting or solid plates (but can include columnar growths)
- Branching is absent (in this case)
- Calice width <1mm
- Corallite centers distinct
- Corallites separate
- Neither axial nor central corallites
- Corallites are widely spaced
- Corallite protrusion immersed
- Tentacles expanded during the day
- Tentacle Length <10mm
- Tissue partially masks skeleton
- Daytime tissue projection <1mm
- Columella absent
- Costae absent
- Unequal septal length
- Radial septa

- 2 cycles septa
- Septa not exsert
- No septal fusion
- Septal height: not exsert
- Septa not petalloid
- Septal margins not smooth
- Paliform structures absent
- Extra-thecal skeleton present
- Extra- thecal surface perforated
- Extra-thecal elaborations present
- Linear elaborations > calice diameter

Methods and Materials

Water velocities were measured with a Marsh-McBirney Flo-Mate 2000 electronic digital water velocity meter. This meter operates on Faraday's Law and reports velocity with a resolution of 0.01 foot per second.

Rates of photosynthesis were determined with a Walz 'Teaching PAM' Chlorophyll Fluorometer (Effeltrich, Germany) equipped with a fiber optic cord. A fluorometer is basically a 'photosynthesis meter' and exploits measurements of chlorophyll fluorescence in order to determine rates of photosynthesis (in terms of 'electron transport rate' or ETR between Photosystem II and Photosystem I within zooxanthellae). Corals were maintained in total darkness for at least one hour before initial measurements were made in order to allow Photosystem reaction centers to 'open'. The external actinic light source was a 400-watt Iwasaki 6,500K metal halide lamp that was shielded for ultraviolet radiation by a clear acrylic material. Intensity was adjusted upwards by moving the light source closer to the coral (which was contained in a 3-gallon plastic container). Light intensity (Photosynthetically Active Radiation, or PAR) was measured with an Apogee QMSS quantum meter and a submersible, cosine-corrected sensor. Water motion was provided by a magnetic stirrer and 3" stir bar.

After the dark-adaptation period, minimum chlorophyll fluorescence (Fo) was determined with a weak pulse of light generated by the instrument's internal actinic lamp. Maximum Fluorescence (Fm) was estimated by increasing the intensity of the internal actinic lamp, resulting in a photosynthetically-saturating pulse of light. Once minimum and maximum fluorescence values are established, the instrument can determine the relative Electron Transport Rate (rETR) under different lighting conditions.

The metal halide lamp was then turned on and allowed to 'warm up' until PAR values stabilized (15-20 minutes). Chlorophyll fluorescence values were determined and the light intensity increased. The coral's zooxanthellae were allowed to adjust to the new light intensity for 15 minutes and another chlorophyll fluorescence measurement was made. This procedure was repeated multiple times, with three measurements taken at each light intensity. These results were averaged.

The PAM meter calculated Photosynthetic Yield, which was simply multiplied by the appropriate PAR measurement in order to estimate the rETR. This is a valid method for observing photosynthetic trends. Technically, it is not the preferred method of determining absolute ETR, but it is fine for our purposes.

Fluorescence was determined with an Ocean Optics USB-2000-FL fiber optic spectrometer (Dunedin, Florida) using an 18-watt black light (maximum emission at 365nm) as the excitation source. Light was collected with a cosine-corrected CC-3 lens and a 600 micron fiber optic cable.

The photograph was taken with a Canon Rebel XTi digital camera (10.1 megapixels) equipped with two stacked teleconverters and a 60mm macro lens.

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FEATURED AQUARIUM

Greg Timms' 130 Gallon Reef

By Greg Timms

This month Greg shares the evolution of his 130 gallon reef aquarium with us.

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I first would like to thank the Advanced Aquarist's staff for all their hard work in creating a first class online magazine. What a benefit it is for us "regular folk" in this great hobby to have a place like this, that with just a few mouse clicks we can access so much valuable information. When Wade invited me to have my reef featured I felt honored yet a little hesitant. I was a little worried my aquarium may not be quite up to the standard people might expect but then thought it's not always about where you are right now but where and what you are striving to be. I hope that through my photos and remarks you will be able to feel the passion I have for this hobby and get a sense of the enjoyment I receive from it. I have always been fascinated with the ocean and diverse life forms we find there. It truly is another world and I love this hobby that allows us to keep a small part of it in our homes. I am grateful to be given this opportunity to share my little piece of the ocean with you.

History & Tank Profile

I ran freshwater aquariums for years, African cichlids mainly and like many people seldom had less that two tanks going at any given time. When I shut my last one down in the late 1980's due to a leak I decided at that time that when I eventually got back into the hobby I would switch to salt water. In October 2004 that dream became a realization when I had a tank custom built. I thought I would begin my salt water adventure with a FOWLR and maybe add in a few soft corals to sway back and forth in the flow. I had seen this kind of display at some fish stores and thought they looked pretty cool. Within about four months I found I was actually buying coral as often as fish and my tank slowly started to become a reef. By spring 2005 I was up to about 24 fish, an RBTA, several LPS with a few leathers and mushrooms as well as some Montipora caps and digitata. My original lighting was a 72" Power Compact fixture which I thought was pretty bright and assumed it was all I would ever need. However, by the summer 2005 I knew I wanted to upgrade to Metal Halides so I could add in some so called "harder to keep" sps coral such as acropora. In July 2005 I upgraded to a 72" fixture with 3x175 watt & 2x 96 watt PC actinics. In September 2005 I added a sump and Dec 05 upgraded my protein skimmer. I once again figured I was all set. Then in summer 06 I added in an RO/DI unit with an auto top-off going to the sump. I finally switched to R/O because I had a major hair algae outbreak that almost killed my reef. It got so bad that I did a complete tear-down in September 2006 and was rethinking whether or not to even stay in the hobby. I obviously kept going which is a decision I am pleased I made. It turns out that my skimmer was running at about 1/3 capacity for several

months which sent my nitrates through the roof. I fixed the skimmer which worked fine for awhile. Right after the skimmer ordeal my main ballast went in my light fixture so I was again at a crossroads. It helped me realize my reef wasn't where I wanted it to be anyway, so in October 2006 I once again upgraded my lighting. I decided on a 72" fixture that houses five HQI bulbs, two 150 watt 20 K and three 250 watt 10 K, that would allow me to create a better sunrise and sunset effect with a higher intensity and then added in some moon lights for extra effect. I have since added a T5 fixture to supplement the lighting to help give that little extra pizazz I had been looking for. Now I was closer to the intensity I wanted but the water was getting too hot. I decided after loosing many sps colonies from the heat that I needed a chiller. After installing the chiller I still questioned why it had to keep running so often to keep things cool, I mean my light was hot but not that hot. Anyway, I did some checking and discovered I had a faulty heater that was staying on 24/7 and this had likely been my biggest problem all along. That said the chiller is still a definite necessity and really helps keep the water temperature stable. Around that same time I also changed out the powerheads to Tunze's with a multi-controller. The difference in the flow and random surge has made a huge difference in keeping my reef happy and growing.

In November 2006 I connected what had been my acrylic 40 gallon cichlid aquarium in-line to use as an ornamental Refugium & Softie tank. The refugium is made up of live rock, soft corals, and macro-algae. This tank has an "old school" sump in the rear where I also keep a "cheato chamber" running on a reverse photo period. I have since added in a 40 gallon frag propagation tank. This has increased my water capacity to approximately 250 gallons. This extra volume along with the increased nutrient exportation has made a huge difference in helping to stabilize the system as well as virtually eliminate nuisance algae growth in the display. Adding more volume to the system meant more water draining to the sump in case of a power failure. Since it will only hold the amount of water that drains from the main display I drilled the sump wall and added an emergency overflow going to a 10 gallon tank. Fortunately, I haven't needed it so far but I am sure the day will come and it helps give some peace of mind against flooding. As you can see the last two years, have been a "reefer's roller coaster ride." It seems whenever my reef starts to do well "Murphy's law" kicks in and something else happens. The summer of 2007 was to be no different. I discovered our dishwasher located in the kitchen, on the floor directly above where the tank is, had been leaking and dripping straight into the tank for an undetermined amount of time. The drain hose had sprung a leak and who knows what chemicals ended up in the tank between the soapy dish water and the basement ceiling tiles, etc. Needless to say I took immediate action. I changed and added extra carbon and did seven water changes in eight days of 15% each and managed to save the majority of livestock but the SPS took a big hit. Most of it lived although I did I loose several nice pieces. Unfortunately what did live either bleached or browned out, but for the most part over the last six months it has bounced back quite nicely. There are still a few pieces I am patiently waiting on to color back up but my hopes are high. Bad things seem to happen in waves, so of course while the dishwasher incident was occurring my skimmer had also quit working. I was without a skimmer for most of the summer and in late August 2007, I upgraded to a much bigger unit that could handle the load. I was very fortunate to not have a huge algae bloom and I give Polyplabs a lot of credit for keeping my nitrates under control as I kept dosing with "reef-resh" during that time. The new skimmer has a 24 inch footprint and is 30" tall so I had to install it away from the main display as there was no room for it. I modified the skimmer to drain into a 5 gallon bucket both as a help for emptying skim mate because it's inconveniently located under the frag tank and as a safe guard against it overflowing. No good sps drama would be complete without having a few "red bug" battles so I of course have had run ins with them and learned the hard way that nothing goes into the system without being given a dip for such pests. I have been lucky so far and never had acropora eating flatworms. Anyway, things have been pretty stable since then so I am keeping my fingers crossed and keep "knocking on wood" that this present trend will continue.

Tank Specifications

- **Main Display** - 130 gallon ½" glass euro-braced, 72"Wide x 18"Deep x 24" High.
- **Refugium** - 45 gallon acrylic hex front with built in rear sump (old school), 48" Wide x 18: Deep x 24" High
- **Frag Prop tank** - 40 gallon euro-braced

- **Sump** - 30 gallon acrylic

Water Parameters:

- **Temp** - 27 C / 79-80 F
- **SG** - 1.026
- **pH** - 8.2
- **Ammonia** - undetectable
- **Nitrates** - undetectable
- **Calcium** - 440 ppm
- **Alk** - 8 DKH
- **Mag** - 1350 - 1400 ppm

Equipment

- **Return Pumps** - Ocean Runner 6500 - Ocean Runner 3500 (return for frag tank)
- **Protein Skimmer** - Euro-Reef RC500
- **Skimmer Pumps** - 3x Eheim 1262
- **Chiller** - Aqua Medic AT5000
- **Lighting Fixtures** - Aqua Medic "*Sexy*" Ocean Light (all HQI) - Aqua Medic T5 fixture 72"
- **Bulbs** - Aqualine 3 x 250 watt 10k & 2x 150 watt 20k - T5's Koralen Zucht 4x 39 watt Fiji Purple
- **Moon Lights** - 2x 1 watt LED (blue)

Refugium.

Frag tank.

- **Powerheads** - 2x maxi-jet (for additional flow in behind the rock work), Seio 820, Hydor Koralia #4, Tunze Nanostream 6045, Tunze *Turbelle* Stream 1x 6000 & 1x 6100 with Tunze 7095 Multi Controller (with single white LED moon phase light)
- **Refugium Lighting** - 2x 96 watt Power Compact 2x 96 watt Actinic Power Compact
- **Filters** - 100 micron pre-filter socks installed in sump beneath tank's overflow and on the skimmer return to improve water clarity and bubble control
- **Heater** - 200 watt titanium heater with Aqua Medic Temperature Controller
- **RO/DI** - Coralife 3 stage with pump
- **F/W Reservoir** - 45 gallon container aerated 24/7 to maintain PH level
- **Top-Off Unit** - Aqua Medic SP3000 Single Dosing Pump

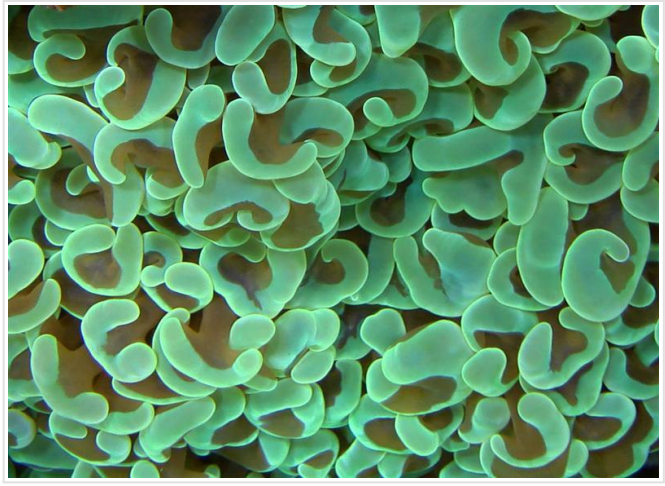
Husbandry

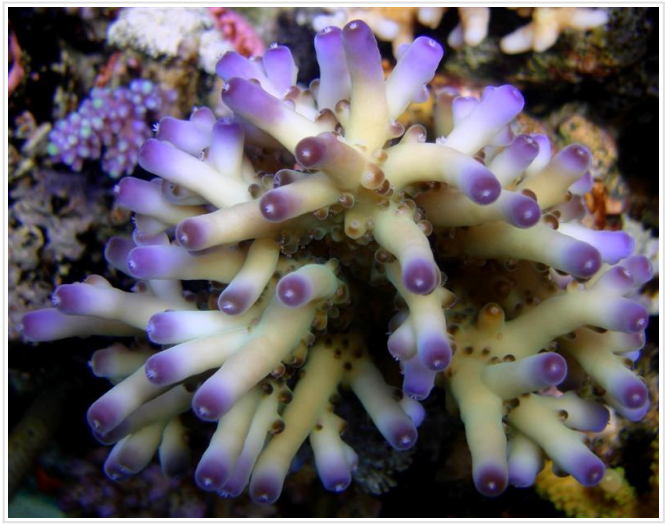
In January 2007 I started running the Polyp-Labs "Reef-Fresh" program which helps keep the nitrate levels in check using bacterial strains, amino acids and other supplements. It is said to give results similar to Zeovit, basically encouraging a low nutrient environment. I have been pleased with the results over this past year or so.

I use Randy Holmes Farley's 2 part recipe for dosing Calcium & Alkalinity. My reef has a demand which requires almost 500 ML of each on a daily basis to keep the levels stable. Magnesium is added at approximately 500 ML per week as per Randy's recipe. Potasium is also dosed daily while other trace elements such as Iodine & Strontium are dosed biweekly.

Routine Maintenance:

- **Skimmer** - empty & clean twice a week
- **Pre-Filter bags** - change twice a week
- **Carbon** - change out monthly (media bag runs through an Aquaclear filter in the refugium)
- **Water Changes** - 10-15% monthly



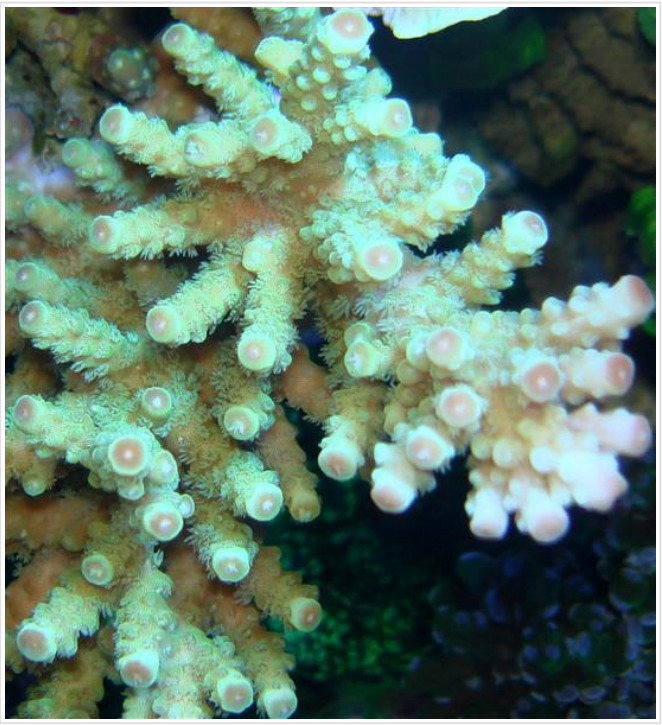


- **Prune & frag corals** - as needed

Lighting Schedule:

Main Display:

- 8:00 AM -1 watt moonlights on 10:30 AM - moonlight off



- 9:00 AM - T5's on 9:30 PM - T5's off
- 10:00AM - 150 watt 20k m/h on 10:30 PM - 150 20k's off
- 12:00 PM - 250 watt 10k m/h on 8:30 PM - 250 10k's off
- 10:45 PM - 1 watt moonlights on 12:00 AM - moonlights off
- white led moon phase light runs automatically via sensor while main lights are out

NOTE: I try to time the photo period in a way in which I can spend more time on the reef while it's active. By starting the lights a little later in the day they are on for a longer time after I get home from work which gives me more time to tinker and enjoy.

Refugium/Softie Tank

- 40 watt light on reverse photo period in the rear sump "Cheato chamber"
- 8:00 AM -actinics on 11:00 PM - actinics off

- 9:00 AM - pc's on 10:00 PM - pc's off
- Frag Tank (250 watt Geisman HQI pendent)
- 9:00 AM - on 9:00 PM - off

Feeding Schedule:

Feeding is provided on a daily basis, generally twice per day, and food is alternated to give their diet a variety of flakes, pellets, brine(super)shrimp, mysis shrimp, cyclopeze and "nori" seaweed. I also mix in some "Reef-roids" or similar product, on occasion to provide some extra food for the corals.

Livestock

Fish & Inverts

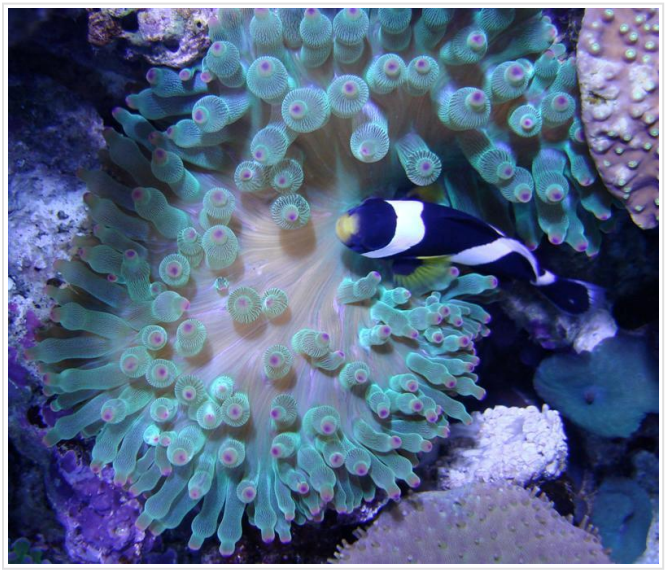
Main Display

- 1-scooter blenny
- 1-yellow tang
- 1-blue tang
- 1-naso tang
- 1-chevron tang
- 1-coral beauty angel
- 1-royal gramma
- 1-bi-colour blenny
- 1-yellow tail damsel
- 1-4 stripe damsel
- 3-green chromis
- 2-black & white ocileris clowns
- 1-blue devil damsel
- 2-watchman gobies
- 1-niger trigger

- 1-black brittle star
- 1- *Nardoa novaecaledoniae* star
- 1 - yellow coris wrasse
- Foxface rabbit fish
- 1-Blood Red hawkfish
- 1-longnose hawkfish
- 1-red serpent star
- Hermit crabs
- 2-conches
- Snails (Too hard to put a number on)
- 1-*Entacmaea quadricolor* (Green bubble tip anemone)
- 5-hawaiian feather dusters

Refugium/Softie tank

- 1-flame angel
- 2-skunk cleaner shrimp
- 1-yellow clown goby
- 1-marine beta
- 1-purple fire fish
- 1-blue striped pipefish
- 2-orchid dottyback
- 1-pencil urchin

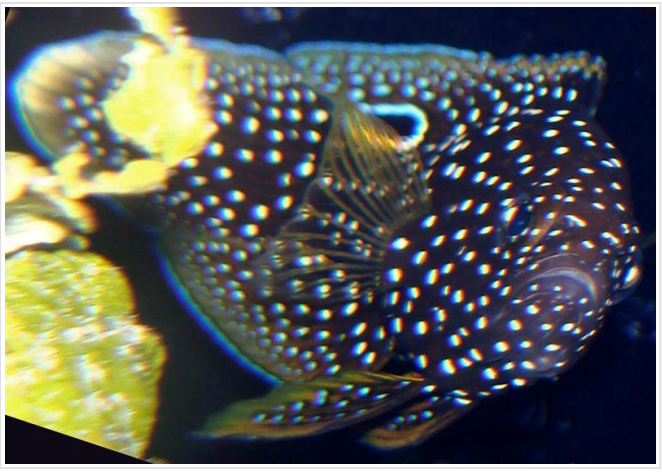


Frag prop tank

- 2-banggai cardinals
- 3-fairy wrasses
- 1-potters angel
- 1-sailfin tang
- 1-rabbitfish
- 1-watchman gobie
- 1-fire shrimp
- 1-sea cucumber

Clams

- 5-*Tridacna crocea*
- 1-Gigis
- 1-*Tridacna maxima*



Live Rock

Approximately 400 Lbs containing a mixture from: Australia, Fiji, Jakarta, Vanuatu, Caribbean & Belize, Hawaii, Mexico & Tonga.

Coral

I don't know all the proper names of many of the corals in my collection so I will only list those that I have identified through research and/or a lot of help from others in the hobby who are more knowledgeable than me. Identification can sometimes be tough when trying to compare an aquarium coral with a picture of one in the wild from a book, especially when you enter reticulate evolution into the equation. With some acropora, I find that I often know what species they aren't but can't always tell exactly which species they are, at least while they're alive. Anyway, I have tried to list the corals by the general taxonomic family first and then by genus and species.

Scleractinian (stony) Corals

Small Polyp Scleractinia

Acropora

A.Loripes, A.Lovelli, A.Rosaria, A.Nana, A.Verweyi, A.Hoeksemai, A.Microphthalma, A.Humilus, A.Gemifera, A.Caroliniana, A.Jacquelineae, A.Prolifera, A.Loisetteae, A.Prostrata, A.Youngei, A.Austera, A.Tortousa, A.Valida, A.Proximalis, A.Millepora, A.Aspera, A.Kimbeensis, A.Batunai, A.Formosa, A.Tenuis, A.Turaki, A.Lokani, A.Horrida, A.Abrotanoides, A.Robusta, AAbrolhosensis, AStriata, A.Pichoni, A.Effloresceens, A.Plana, A.Pulchra, A.Subulata,

A.Aculeus, A.Insignis, A.Maryae, A.Cerealis, A.Echinata, A.Bifurcata, A.Convexa, A.Chesterfieldensis, A.Divaricata, A.Hyacinthus, A.Convexa, etc.

Pocilloporidae

Pocillopora Damicornis, Pocillopora Verrucosa, Stylophora Pistillata, Stylophora Subseriata, Seriatopora Hystrix, Seiatopora Caliendrum, Seriatopora Stellata.

Montipora

M.Digitata, M.Capricornis, M.Danae, M.Verrucosa, M.Capitata, M.Confusa, M.Samarensis, M.Flabellata, M.Tuberculosa, M.Aequituberculata, M.Undata, M.Setosa, etc.

Misc SPS.

Hydnophora Pilosa, HydnophoraRigida, Porites sp., Merulina Scabricula, etc.

Large Polyp Scleractinia

Lobophyllia sp, Symphyllia sp, Caulastrea Furcata, Echinopora sp, Favia Speciosa, Trachyphyllia Geoffroyl, Euphyllia Ancora, Euphyllia Divisa, Turbinaria Peltata, Acanthastrea Lordhowensis, Acanthastrea Echinata, Turbinaria Reniformis, Echinophyllia Aspera, Mycedium Elephantotus, Oulophylia sp, Duncanopsammia Axifuga, etc.

Soft Corals

***Corallimorpharians* (mushroom corals)**

Rhodactis, Actinoddiscus (=Discosoma) Striata, Mutabilis, Cardinalis, etc.

Octocorals

Tubipora Musica, Xenia sp. , Alcyonium, Lobophytum Pauciflorum, Sarcophyton Elegans, Sinularia Notanda, Sinularia Dura, Capnella Imbricata, Heliopora Coerulea, etc.

Gorgonians

Briareum Asbestiumi, Rumphella

Zoanthids (Various species)

Pachyclavularia Violacea (green star polyps)

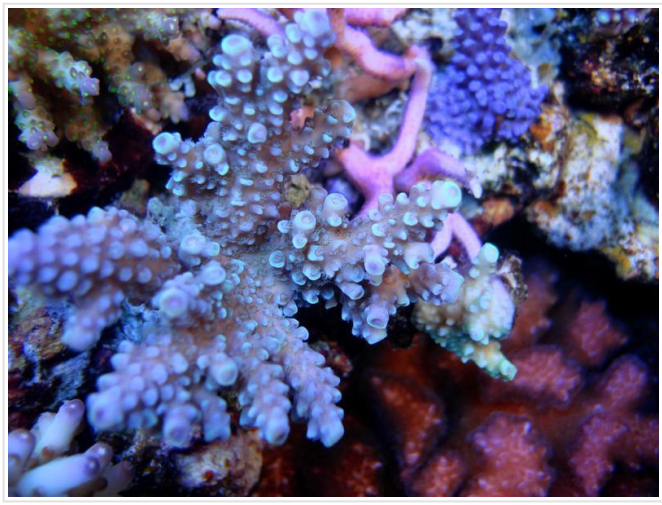
A Few Comments I've heard:

In Michael Paletta's book "Ultimate Marine Aquariums" he asks his subjects about some of their favorite remarks people make when they see their reefs. I hope he won't mind me borrowing his idea as I thought it's a good one and I often get a kick out of people's reactions when they see my reef for the first time. Here are just a few first time comments:

- *Oh my gosh, I've never seen anything like this before.*
- *Is that salt water? Is all that stuff alive? Are those plants? They're all corals? Even those? Are they real? How did you get them?*
- *Do you bring these back when you go scuba diving?*
- *I used to have goldfish but it wasn't like this.*
- *I've been diving before and it wasn't nearly as colorful as this.*
- *One reaction I find quite rewarding is when people simply stand there and say wow. (repeatedly)*
- *But being of Christian faith, I think my all time favorite comment was when one individual out of the blue stated "I've always believed in evolution but after seeing this I think there must be a creator."*

Acknowledgements

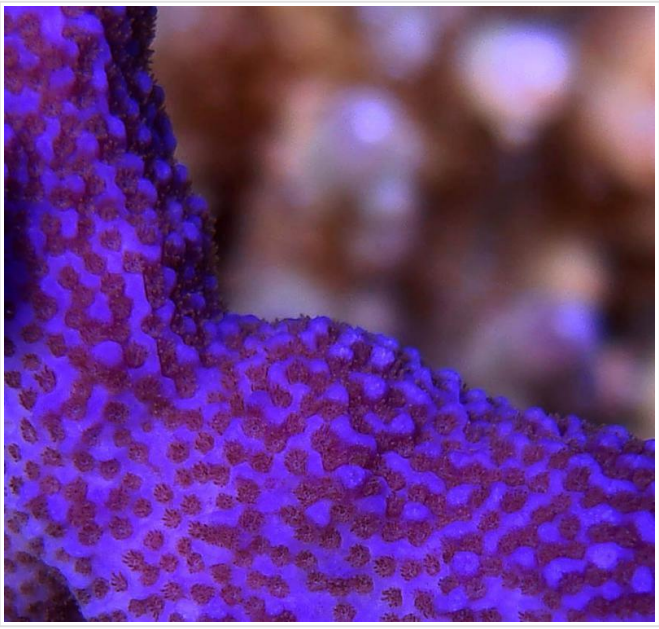
I would once again like to thank Advanced Aquarist's for their interest in featuring my reef and as previously mentioned it's an honor. I also want to thank all the people who have helped to educate me and given their support since I got started. I would also like to thank the suppliers that have put up with my bending their ear trying to learn from their knowledge. There are so many people I have learned from, too many to mention here but I again want to thank all those who have willingly shared their knowledge, time and friendship. Thanks also to Mike Paletta who was very gracious in giving his blessing when I asked to borrow his



idea. I especially want to thank my wife Penny for her years of unquestioning support and always giving me plenty of room to run with my dreams.

Summary

My aquarium's look and especially my tastes have continuously evolved. This amazing hobby has taken me up and down and back and forth, through euphoric feelings of reward to great depths of frustration. It is said that experience is what you get when you were doing one thing and expected something else. All the "school of hard knocks" experiences along with my desire to learn and improve have brought me to where I am today and I wouldn't trade them for anything else. There are of course many things I would do differently if I had a "do-over" but overcoming challenges and hard lessons are often the best teachers. I still have much to learn and am never satisfied for very long with what I've achieved so more changes to my reef are imminent. But for now anyway, I have what I would call an "SPS dominated Mixed Reef." With my reef continually growing and corals so often crowding each other, I have found that regular pruning is necessary so starting a "frag business" became the next logical progression of the hobby for me. Having frags available creates an opportunity for me to meet lots of great people in the hobby, make a lot of cool trades and even get a few costs covered now and then. This hobby has had quite a profound effect on me and has even changed the way I scuba dive. I used to mainly look for the big things; dolphins, rays, turtles, sharks, eels, etc which I will always enjoy seeing, but since having my own reef I spend more of my dives looking at coral details and the small things many people miss such as Christmas tree worms, nudibranchs, flatworms, tunicates, etc. I enjoy it more than ever. I hope that my write up and pictures have provided a little something for everyone to enjoy and that my love for the hobby is apparent through my story. I wish you all good luck and happy reefing.



BREEDER'S NET

AMAZING ARTEMIA!

By Suzy Q Applegarth

I have found it possible (actually very easy) to have a continuous culture of brine shrimp.

Published March 2008, Advanced Aquarist's Online Magazine.

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Keywords (AdvancedAquarist.com Search Enabled): Breeder's Net, Breeding, Suzy Applegarth, aquaculture
Link to original article: http://www.advancedaquarist.com/2008/3/breeder

One of the most interesting landmarks in the State of Utah is the Great Salt Lake. Tourists flock here in the summer, to test the buoyancy effect the high salinity level provides. Those of us who live here always find it interesting to see tourists voyage into the water, and the look on their faces is always amusing! Obviously, it is not what they expected.

The Great Salt Lake is what remains of a huge lake once known as Lake Bonneville. Over the millenniums, the water evaporated, leaving the salts behind and increasing the salinity of the water. As the salinity rose, the species of fish able to adapt to the elevating salt levels plummeted. Eventually, only one remained: Artemia. Not a fish at all, a crustacean. A shrimp, to be precise. Without any predators, this species has thrived.

Now, in 2008, this lake is in the midst of a large metropolitan area. The rain that feeds our lawns runs off into rivers that feed the lake, and the lake is high in nutrients from our lawn fertilizers. This environment, during the warm months, is a predator-less paradise where the artemia gorge on the abundant microalgae, grow rapidly and reproduce live nauplii. Because their diet is so abundant in various microalgae, their colors vary, ranging from dark to light red and green. When the cool weather begins, these shrimp begin producing cysts that are ready to hatch the next spring. The artemia then die, producing a stench smelled for miles. The brine shrimp eggs (or cysts) produced are large and abundant.

HATCHING OUT THE CYSTS

Techniques for hatching out these cysts vary. You can decapsulate the cysts (remove their shell) using a 1:3 part solution of FW and household bleach to remove the shell. Use a covered container to gently toss the eggs in the bleach solution and rinse well when they turn orange. I use a micro sieve to rinse them. You can use a spaghetti strainer lined with a coffee filter. These eggs are great to spot feed your corals, but will not hatch as easily. The shell is what creates their buoyancy.

I use a lot of artemia to feed my fry and my corals, so I do not go to the extra step of decapsulating. My fry are very discriminating about only eating motile food and I have not had an issue with shells. Some feel the extra step of decapsulating is worthwhile, so evaluation of your particular need is important.

I have tried a few commercially available hatcheries and the best I have tried thus far is the inverted 2 liter soda bottle. When cut in half and the top placed into the bottom, a vessel is created that encourages the heavier unhatched cysts to sink into a small area that houses a piece of rigid airline tubing. The rigid tubing is attached to a piece of flexible tubing to bring air from a small pump. Using a gentle flow, the air bubbles then lift the cyst up and into the water column. As the brine shrimp hatch, the empty shells float. After a day, I turn off the pump and wait a few minutes, then siphon the live brine shrimp from the bottom of the vessel, leaving the last inch of shells in the vessel to be rinsed into the sink.

When the cyst is newly hatched, and it has not yet consumed its egg sack, it does carry some nutrition. Some sources I have read say it is a few hours to up to a day. I have found it difficult to tell exactly when the cyst has hatched, thus making it difficult to say when the brine shrimp has lost its value. You can evaluate with a microscope, but that is a tedious step when I want to feed and go on with my life. So, I just enrich them. I look at these tiny napulii as a grocery sack, carrying the real nutrition into my aquatic home.

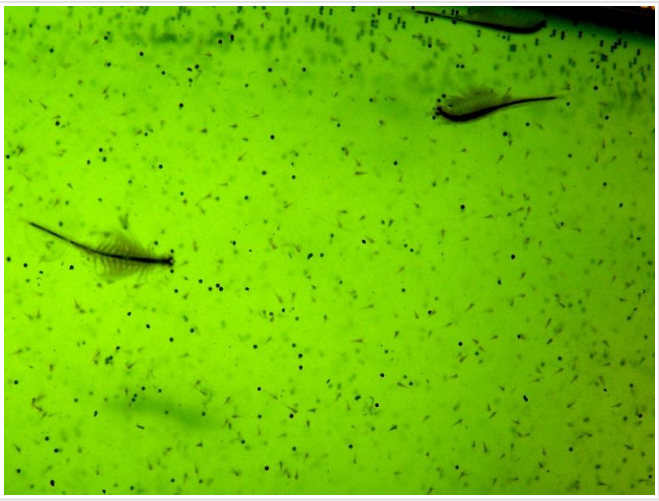
To enrich really means to gut load. I feed the nauplii the products I am trying to deliver to my tank: phytoplankton paste and concentrates; a fatty acid supplement, Selco; even medications or Betaglucan. Brine shrimp are filter feeders after their second molt so they will consume what ever is in their random path. According to Brine Shrimp Directs website, the fatty acid supplement Selco not only gets consumed, it "sticks" to the napulii. I keep the hatched artemia in a jar with an air line and just enough phyto paste to tint the water green for days. I use a turkey baster to feed a bit to my reef just before the lights go out. If you have a smaller tank, you may want to drain the water to avoid adding excess nutrients to your system.

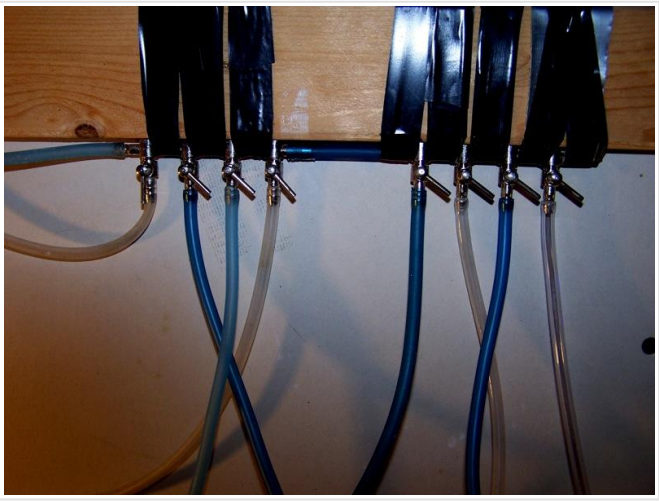
I have found it possible (actually very easy) to have a continuous culture of brine shrimp. It takes around 2 weeks for a nauplii to grow into an adult. At that point, they produce live nauplii. I use a simple 2 gallon container. I feed just enough phytoplankton concentrate to keep the water tinged green. I place an airline in and a piece of macroalgae for filtration, and keep the culture in a brightly lit area. I harvest a cup a day, filtering the water out into the drain, and then releasing the live adults, almost adults and the napulii into my reef. The chase begins and the fish love it!

Tips:

- I use old tank water from my last water change to hatch cysts. Room temp works great. If you fill the bottom of the 2 liter hatchery with hot water, you can hatch the batch quicker if you need BBS fast. Also, having the water weight in the bottom makes the hatchery much more stable.
- If you have multiple hatchers and grow out containers, using different colored tubing from your gang valve will make it easier to visualize which tube is going to which culture vessel. It is helpful when trying to adjust the bubbling to the proper flow. It is a necessary to find the right flow: too much flow will push the cysts out of the water; too little and the cysts sink to the sides of hatchery.

More information about these amazing shrimp can be found at: http://ut.water.usgs.gov/greatsaltlake/index.html





REEFKEEPING EVENTS

What's Happening in Your Area?

By Advanced Aquarist Readers

Check to see if an event is happening in your area!

Published March 2008, Advanced Aquarist's Online Magazine.
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Keywords (AdvancedAquarist.com Search Enabled): Advanced Aquarist Readers, Reefkeeping Events
Link to original article: http://www.advancedaquarist.com/2008/3/events

Do you have an upcoming event?

If so, please email us at feedback@advancedaquarist.com and let us know about it!

Marine Aquarium Expo, Saturday, April 5-6

The First Annual Marine Aquarium Expo (MAX) is a TWO DAY EVENT at the Orange County Fair & Exposition Center (Costa Mesa, CA) April 5-6 2008!

Dates and Times:

- Saturday, April 5th 12:00 noon to 8:00 PM
- Sunday, April 6th 10:00 AM to 6:00 PM
- Calendar Information

Event Information:

- Over 100 exhibitor's booths!
- Manufacturers, Wholesalers, Retailers, Exhibitors
- Livegoods/Drygoods for sale throughout the building
- 8 major Speakers lined up! (4 per day)
- Multiple Workshops and Demonstrations
- Children's Petting Pool and education area (pending)
- Frags! Frags! and more Frags! need I say more?

Admission: Adults $10.00, Seniors $5.00, Children 12 & under are Free!

MAX is held in Building #12, (22,000 sq. ft. fully-enclosed, air-conditioned exhibit hall). An adjoining 7,000 sq ft. covered courtyard will host much of the peripheral activities (speakers, workshops, raffles, seating area, etc.). This greatly enhances the space available inside building 12 for commerce. In other words: More room for everyone!

HUGE RAFFLE at the end of each day! Special Note: 50% of ALL Raffle Proceeds will go to 10 select public charities, all of whom are participating in MAX either directly or indirectly. (some represented by hobbyists doing a workshop on behalf of the charity)

This is a VERY family-oriented event, so please plan on bringing the entire family for a weekend of spectacular exhibits, speakers, workshops, displays, and other entertainment. Great food, clean restrooms, even a seating area.

Ladies and Gentlemen, this event is expected to attract over 3,000 hobbyist from all over the United States! Participating vendors and attendees alike are coming from all parts of the country. In fact, MAX is soon to become the largest event of its kind in the entire North American continent in terms of overall attendance. You don't want to miss this one!

For more information, visit us at: http://www.marineaquariumexpo.com

Contact Information:

Kevin T. Adams, MBA, Promoter
"Marine Aquarium Expo 2008"
8072 Central Avenue
Garden Grove, CA 92844
info@MarineAquariumExpo.com
(714) 530-1094 office
(714) 260-6660 cell

(please note: MAX is not affiliated with any club organization)

North Central Pennsylvania Aquarium Reef Society Spring 2008 Frag Swap Event, April 12

Date: April 12, 2008
Time: 10:00 AM - 4:00 PM
Location: Whitmore Labs, The Pennsylvania State University, University Park, PA 16802 (maps: Campus, Directions)
Website: http://fragswapper.com/setmeeting.asp?MeetingKey=36

Topic: Fish and Coral Husbandry Techniques
Speaker: Kevin Kohen

Drawing on Kevin's vast experiences, this talk will address the important questions that most hobbyists are faced with when dealing with fish and corals:

- Best practices in acclimatizing fish and coral
- Treatment of Common Fish Diseases - What works
- Care of fish in Quarantine
- Getting difficult fish to feed
- How to avoid Coral Pests
- Dealing with Coral Pests in the aquarium

Admission:

- NCPARS Members - Free
- Non-Members - Individual - $15
- Non-Members - Family (same household) - $25

CTARS Marine Aquaium Conference, April 13

Date: April 13, 2008
Time: 9 AM - 5 PM
Location: Courtyard Marriott, 4 Sebethe Rd., Cromwell, CT
Website: http://www.ctars.org/default.aspx?uc=conference

Featuring:

- Adam Blundell
- Mystic Aquarium
- Joe Burger
- James Fartherree
- Huge Raffle
- Club Frag Swap
- Vendors

No tickets will be sold at the door.

14th Annual All Ohio Frag Swap, April 13

Sponsored by C-SEA

Date: Sunday, April 13th, 2008
Time: Noon to 4 pm, with HUGE raffle beginning at 3 pm
Location (same site as last year):
American Legion Hall, Clifton Post
22001 Brookpark Rd
Fairview Park, OH 44126

Directions are available at the C-SEA website: www.c-sea.org

Admission $5 per adult; under 14 yrs old is free.

- Admission gets you 4' of table space and 4 hours of frag swappin' madness!
- Electricity available (within reason--leave the 1000W MH at home please)
- Doors open to swappers at 12 noon
- Food available in attached restaurant and bar (we'll try to make sure the cook has more help this year!)
- Plenty of free parking.

And don't forget the dry goods raffle at the end of the swap! $1 per ticket; $5 for 6 tickets

More information to follow on attending vendors. The swap had over 350 attendees through the door last year. Lots of frags for sale/trade.

Second Annual Tidewater Area Marine Aquarium Symposium, April 26

Date: April 26, 2008
Time: 1:00 PM
Location: Virginia Aquarium and Marine Science Center, 717 General Booth Blvd., Virginia Beach, VA. 23451
Website: http://www.tidewater-reefers.org

The topics this year will be: Marine Aquarium Chemistry and Reef Nutrition

The two speakers for this event will be Chris Jury and Randy Reed. Chris will be speaking on Marine Aquarium Chemistry and Randy will be speaking on Reef Nutrition.

This event will once again be at no cost to TRS members in good standing. The cost to non-members will be $7.00 for advance ticket sales and $10.00 at the door. The Virginia Aquarium and Marine Science Center auditorium has limited seating and advance purchase of tickets is strongly encouraged for non-members wishing to ensure they get a seat. Those that purchase advance tickets and later decide to become members of TRS (and we hope you will) may have their membership dues reduced by the amount paid for their ticket. This offer will extend up to the day of the event.

Seating is limited and all TRS members will get priority seating and free tickets. Advance tickets can be purchased by arrangement with a TRS officer and may soon be available for online purchase like last year. Non-member tickets will be sold first come, first serve. Feel free to email president@tidewater-reefers.org to make arrangements for advance ticket purchases.

Manhattan Reefs 2008 Spring Frag Swap, April 27

Date: Sunday, April 27th, 2008
Time: 10:00 AM - 6:00 PM
Location: Pratt Institute, Brooklyn, New York
Cost: RSVP - 1 Member - $20 (Pratt Institute Students admitted free with Photo ID)

Guest speakers:

- Jake Adams: Carribean Corals
- Richard Ross: "Welcome Ceph Overlords"

There will be three Pratt Aquarium tours throughout the day. The fragging demonstration will be presented by Tristan Wilson.

And as usual, admission includes:

- Manhattan Reefs Frag Auction
- Free Raffle Tickets
- Reef Pest Inspection Station
- Equipment manufacturers
- Livestock vendors
- Several group buys
- Food, snacks, soft drinks
- Baggies, rubber bands, warmed saltwater

Vendor Tables are still available. If you are interested, please send an email to admin@manhattanreefs.com.

Midwest Frag Fest, May 3-4

Date: May 3-4, 2008
Time: Saturday (9 AM - 5 PM), Banquette @ 6 PM; Sunday (9 AM - 2 PM), raffle 3 PM
Location: Clock Tower Resort and Conference Center, 7801 E State Street, Rockford, IL 61108-2721, US
Website: http://midwestfragfest.com/index.html

Midwest Frag Fest is the premier coral conference across the midwest. Frag Fest 2008 will be held on May 3rd and 4th at the Clock Tower Resort and Conference Center located just off of I-90 in Rockford IL. Our goal is not only to provide both hobbyists and vendors across the region with the best experience at an event of this type, but to donate a portion of the proceeds towards reef conservation and also give back to the community. Admission will be discounted with the donation of canned goods for a local food pantry.

Attendee information:

- Hotel accommodations are available at a reduced rate at the Clock Tower Resort for only $94 per night.
- Full event pass includes admission to all speakers, trade show and frag area, banquet dinner, and event T-shirt . The cost is $55. Sign up fast. First 40 to register will sit at a speakers table at the banquet. What a wonderful opportunity to chat with the pros
- One day pass with all access for that days events are available as follows:
  - Saturday with dinner $45
  - Saturday with out dinner $20
  - Sunday $20
  - Trade show, fragging area only $10
  - All at the door admissions reduced by $1 per can good donated up to $5 off

Speakers include Adam Blundell, Rod Buehler, James Fatherree, Mike Paletta, Gary Parr, Steven Pro, and Randy Reed.

International Marine Aquarium Conference '08, May 30-June 1

Just Imagine...a weekend where you can see live presentations by the most widely known, well-respected authors and lecturers in the marine aquarium hobby.

At the International Marine Aquarium Conference the speakers will be covering all the latest information and research on marine aquarium fish, corals and invertebrates. Meet with them socially, see exhibits by some of the foremost manufacturers and dealers in the aquarium hobby, and get some great deals on conference specials.

IMAC is open to ALL hobbyists . You do not have to belong to a marine aquarium society or even own a reef tank to attend, just be interested in learning more about this fascinating hobby. IMAC is a non-profit venture by hobbyists for hobbyists to insure the continuation of an annual educational event for aquarists, at a reasonable cost.

Whether you are a seasoned aquarist or just a beginner, IMAC is something you need to take in. And IMAC is put on each year by the same people, so if you attended IMAC in 2003, 2004, 2005, 2006 or 2007 you know the high quality of the show that we will put on.

IMAC 2008 will take place in Chicago, Illinois, USA - May 30, 31 and June 1 at the Crowne Plaza Hotel, Chicago IL:

Crowne Plaza Hotel, Chicago O'Hare
5440 North River Road
Rosemont, IL 60018, USA

For more information, visit http://theimac.org/ or contact Dennis Gallagher.

Reefkeepers Weekender, August 29 - September 1

Date: Friday, August 29 through Monday, September 1, 2008
Location: Pontins, Pakefield, Suffolk (2 hours from London, 3 Hours from Birmingham)

The Reefkeepers Weekender has grown steadily since it's inception, and last year was a really fantastic weekend, with superb presentations, a Quiz, brilliant raffle prizes, cabarets, plenty for the kids, and LOTS of late night chat (and a fair bit of Resolve sold in the shop!).

The highlight of the weekend will be, in additon to the usual raffle and quiz, presentations by none other than world renowned experts:

- Mr Anthony Calfo, Author of two of the "Bibles" of reef keeping, "The Book of Coral Propagation" and "Reef Invertebrates" amongst others. Anthony has also recently had articles in "Ultra Marine" magazine.
- Top Dutch expert, Mr. Ron Hessing. Ron writes for Koralle magazine in Germany, A Journal in the USA, and his own site www.marineaquarium.nl and has spoken publically at events around the world, most famously, MACNA and the Boston Reefers Society.

As well as these eminent experts, there will be other presentations, to be confirmed. Details of what their presentations will be will follow a bit nearer the time.

It is essential that you book now if you want to come this year. Last year, the holday park was full, and some of those that wanted to come were disappointed. So, don't delay your decision this time people. It is bound to be over subscribed with a line up like this, so get in there and secure your place. You need to contact Pontins, Pakefield to book on 01502 502 900. Tell them it is for the Reefkeepers Weekender, and make sure you give them your UR name as well your real one, so that we can issue badges.

For 3 nights Fri, Sat and Sun, it is £60 and half price for Under 18's. This is half board, so a full Breakfast and Evening Meal each day are included. There will be Trade Stands and Give-aways too, and, of course, a chance to meet up for our annual chin wag and party! You do need to book this now! It has become one of the leading UK meets of the year and you don't want to miss it!

MACNA XX, September 5-7

Presented by Atlanta Reef Club and MASNA, MACNA is the largest hobbyist marine conference in North America. New aquarium products, vendors will often wait until MACNA to release new products into the hobby. Hobby professionals, you will have a chance to meet and mingle with professionals in the hobby like Eric Borneman and Anthony Calfo. A chance to be at a conference with hundreds of other people just as obsessed with aquariums as you are.

We have selected the Westin Peachtree Plaza as the host hotel for this event. It is the tallest hotel in the western hemisphere. Our negotiated room rate is $119.00 per night with discounted parking. Everyone that stays in the hotel will be given free internet access from their rooms.

This 73-story tower, topped by the revolving Sun Dial Restaurant, Bar & View, graces the heart of Atlanta. Connected to AmericasMart, The Westin Peachtree Plaza, is steps from CNN, Georgia Aquarium, Georgia World Congress Center and the Georgia Dome.

Contact Information:

MACNA XX
1266 West Paces Ferry Rd.
Suite 194
Atlanta, GA 30327
PHONE:
FAX: 860.540.2351
E-mail: info@macnaxx.com
Contact Form

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Contact our Chief Editor, Terry Siegel, at terry@advancedaquarist.com and get started!

AQUARIUM FISH

Large Angels in the Home Aquarium, Part II

By Jim McDavid

With a little thought, a little planning and a desire to provide the animals in your care with research, there is no reason why you can't keep one of these beauties healthy for 15+ years in your living room!

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Welcome back! Last issue we began discussing the larger marine angelfish and the requirements to keep them successfully in the home aquarium. We talked about space requirements; as well as how to make sure that the variables are on your side when you go to select a specimen at your local store

This time, we'll talk about how to properly introduce your newly acquired angelfish into his new home, how to properly feed it, and some information on a few of the more commonly seen species in the hobby.

What about filtration?

Marine angels need perfect water conditions for the most part. While a few species are a bit more forgiving in this regard, and one or two are arguably "bullet proof" (I'll deal with these species later), most of them will not suffer neglect or laziness on the part of the keeper with the same aplomb as your average damselfish. Tank size goes a long way toward mitigating water quality fluctuations since the greater volume means that dissolved metabolites are more diluted and have less of an effect on the organisms within the tank.... in theory. This of course only holds true if the aquarist avoids stocking the tank in such a way that the "large" volume of water is negated by too many fish, or fish that are too large - something that is easily done with marine fish, and all too common. It's very easy to bring home a fish from your local store that will overwhelm a 1000-gallon tank as easily as a 100-gallon tank. A 150-gallon tank that provides a nice piece of real-estate for an Orchid Dottyback gets very small, very fast when an 11" annularis angel is placed inside of it! Such a scenario is far too common however. Go as large as you have the space and funds for, and pick your angelfish accordingly!

Further, effective filtration is a must! Angels are very sensitive to poor water quality. The best way to provide appropriate water conditions is a combination of live rock, protein skimming, and water changes. A large refugium with a healthy growth of macroalgaes certainly helps as well. Angels are grazers, and consume a large volume of food on a daily basis. A 10" angel consumes a respectable amount of food, and projects a corresponding amount of waste matter into the tank. Maintenance regimes will vary considerably depending on all factors, including the size of the tank, the number and types of other fish present, how much live rock or other filtration is present in the system, feeding regime, etc. A 300-gallon reef housing a 6" Regal Angelfish along with 20 or so other small fish will be a very low maintenance proposition indeed. On the other hand, that same size tank with a 10" imperator angelfish, along with a few other larger marine fish species and a smaller amount of live rock might require a 20% water change weekly in order to maintain proper water conditions.

As far as decor goes, this is slightly dependent on the age of your angel, and to some extent species. You'll find that you will see youngsters or initially shy species such as *P. navarchus* out in the open more often if they know that they have a plethora of hiding spaces close by. This need for numerous caves and overhangs lessens just a bit in some species as the fish matures, but never disappears, and is essential while the angel is growing and becoming accustomed to his new environment. A lack of hiding places will cause the animal stress, something we want to avoid at all costs.

I'm ready to bring him home already! What else?

Not so fast! We'll discuss stocking order in a minute, but first I have to mention the all-important factor when introducing a new fish, especially an angelfish - **quarantine**. This word seems to be the bane of many inexperienced (or unwise) marine aquarist's existence. It seems that the minor amount of effort and expense, relatively speaking, is just too much for them to be bothered with. That is, until they suffer the consequences of skipping this step - then suddenly the trouble and expense of a quarantine tank seem miniscule in comparison to dealing with a pathogen that has invaded their display system and starts wiping out fish! It never ceases to amaze me how many fish keepers are ignorant of just how important proper quarantine procedure is to the longer-term success of any closed system. The bottom line is this, if you can't afford to set up a small quarantine tank, then you cannot afford to keep a marine fish display tank - it's really that simple. A similar statement can be made if pure laziness, or simply space is the limiting factor. Over the years I've typed more words admonishing lazy or nonexistent quarantine procedures while responding to "help, my fish has ich!" threads on online forums than all the words in both parts of this article combined several times over! Even the most inadequate effort into the basics of marine fish husbandry will yield information on the importance of quarantine, thus anyone not doing so is either ignoring such wisdom, or had not bothered to investigate at all how to keep these animals alive. Neither scenario puts this author in the most compassionate of moods! If you neglect to quarantine your fish, you

will have problems sooner or later - this is never truer than where relatively delicate species are concerned.

Terry Bartelme has written an excellent article on proper quarantine procedure, and the reasons for it, which can be found here. I'll leave you to it, and simply add that quarantine is absolutely necessary not only to ensure that your new acquisition does not succumb to disease, but also to ensure that you do not introduce disease organisms into your display tank.

When do I add my angelfish to the display tank?

This gets tricky folks, and it depends on many factors. I would submit that if the well being of our angel is the primary concern, then most species should be the first fish added to the display tank - with the possible exception of a few dither fish such as Chromis virids. Not only will the presence of these dither fish make the angel more at ease, and speed up acclimation to the display tank, but it's an absolute *must* that the tank be well established and healthy before any species of angel is introduced. The pugnacious nature of some species toward newly introduced fish however, (and sometimes just any other tank mate in general) as well as other mitigating circumstances dictates that adding the angel to your display first is not always the best course of action. A few species are even hardy enough to allow their introduction whenever convenient. At the very least then, young individuals or more delicate species of any age should be added first when possible, or at the very least before any other fish that will compete with it for food or hide spots. *P. navarchus* and *P. diacanthus* are best added first, and the same goes for *P. imperator,*. *P. asfur* and *P. annularis.* There are also species, which should almost always be added last due to their more pugnacious nature. Chief among these are *H. passer*, and *H. ciliaris* - as well as *P. paru*. Please note that just because an angel is potentially aggressive, does not mean that newly imported specimens are not somewhat fragile, even if behavior is assertive and the fish looks like he has things handled. Often all seems well until a disease outbreak. Take steps such as rearranging the rockwork to break up existing territories, and do not introduce an angel into a tank containing a well-established and aggressive species such as triggerfish or a Dragon Wrasse. There is not always a perfect solution to problems presented with stocking order, and more often than not a compromise has to be made. For instance, I would normally suggest that due to its fragile, temperamental and extremely shy nature, a young Majestic Angel always be added to the display first, or after a few dither fish. Although this means he may cause problems with further additions to the tank later on, we can take steps to mitigate this, (rearranging the rockwork to break up existing territories for instance) and it's more than worth it to get him established, eating well and healthy.

A big reason for the caution I'm advocating here is something that many aquarists do not realize about these fish, and that is that the moderately hardy to delicate species go through a prolonged period of acclimation - longer than casual observation will make manifest. The most important thing to keep in mind here is that their immune response often does not function at full tilt until months after they are seemingly established in a display tank. There is no hard answer to how long this period is, as it varies greatly from individual to individual and the circumstances involved. What this means is that you may have quarantined your angelfish properly, and he may be swimming around in your display and all may look fine and dandy for weeks. Quite often the reality is that the fish is still in a state of low-level stress, has not fully acclimated to the surroundings, and is moderately susceptible to disease still. At this stage, there are many things that can send the fish into a tailspin. Among these stressors are inadequate shelters, low quality of food or inadequate feedings, temperature or pH fluctuations, nitrogen spikes, and the one we are concerned with here, harassment by a tank mate.

Harassment can be as subtle as twitching or arching the body and tail on the part of the aggressor, or as blatant as out and out chasing. The simple matter of the resident fishes having claimed the best shelters is enough to cause your new angel a modicum of stress, even if no other aggressive interactions are apparent. In any case, this spells bad news for any new addition to a display tank, and doubly so for a juvenile angelfish not yet fully acclimated to it's new home - even a species that will later likely become aggressive itself such as those species noted above. Again, we want to do everything possible to allow the angel to establish itself - competition during feeding is eliminated for a time, and stress will be drastically reduced during this critical period. While juvenile specimens in the 2 to 4 inch range are always best since they acclimate more readily than smaller or larger specimens, it's especially important to heed this with aggressive species such as *H. passer*. Purchase one that is too much larger than this, and you'll cause the same problems with later additions to your tank as we sought to avoid with the angelfish!

What do they eat?

Providing proper nutrition is arguably THE most important factor in maintaining the prolonged health of your angelfish, and one of the greater challenges. In the wild, the diet of marine angelfish varies from species to species. The diet of one species may be very eclectic, as is the case with *P. semicurculatus* and *P. navarchus*, to decidedly specialized, as is the case with *P. diacanthus* or *H. tricolor*. Often, difficulties with feeding is the downfall that plagues the aquarist who has otherwise managed to procure and acclimate a healthy, vibrant angelfish specimen, only to watch it succumb to illness brought on by malnutrition. A consistently widely varied diet is the key here, along with vitamin supplements, which can be applied directly to the food, usually by soaking the food items in the vitamins before feeding.

Angels are consummate grazers in the wild, and some of them, most notably those of the genus *Holocanthus*, are obligate spongivores - that is they feed almost exclusively on sponges in their natural habitat. Even most species that are not sponge specialists nevertheless ingest a fair amount of sponge matter, such as *P.paru* and *P.imperator*. This can pose a huge problem for the would-be angel keeper since sponges are not normally found at the local grocery store. Furthermore, even a species with more eclectic feeding habits such as P.navarchus can be difficult to get acclimatized to captive fare at times, necessitating a sort of shotgun approach until something is accepted. Once that happens, more foods will be accepted over time.

Fortunately, there are some very high quality angel preparations on the market these days that contain many of the vital dietary components of our Pomacanthid friends, including sponge matter and algae. Aside from sponge matter, which we normally can only feed in small amounts due to practical considerations,

macroalgae is also of primary importance. As with sponge matter, the high quality frozen preparations mentioned here provide some of this, but it can also be purchased in dried form from certain stores, as well as grown in a refugium by the aquarist. Other food items that can and should be offered in rotation are high quality flakes such as OSI and Formula 1 and 2 (both flake and frozen versions) frozen preparations such as Prime Reef, VHP, Angel Formula, Pygmy Formula etc, along with mysis shrimp, plankton, silversides, krill and brine shrimp. Anything available at your local fish market should also be fed, such as crab, squid, scallops, octopus, halibut, oysters, clams, shrimp,etc.

What if he won't eat?

Assuming we're not talking about a chronically problematic species in this regard, an angel refusing to eat is a common stress reaction, but fortunately a problem that is in many cases only fleeting. For starters, it's always best to ask to see the fish eat in the store before you bring it home. Of course the fish may greedily gobble down brine shrimp in the store, then refuse food again for a time once you have him in his quarantine tank - but at least you know that the problem will right itself in a matter of days. Other times their refusal of food in the store is not necessarily an indication that you should steer clear of the fish, especially with very shy species. At the end of the day this is a judgment call, and the keeper should be aware that some fish that don't eat initially will NEVER eat, or else don't eat enough. This is most often true with very tiny specimens, adult specimens, or certain problematic species such as *H.tricolor* or *P.diacanthus* - two species that frankly should be avoided by most hobbyists anyway.

Getting a newly acquired Pomacanthid to eat that is stubbornly refusing everything offered is truly an exercise in patience and resolve. After all, the clock is ticking! As the interval of time that the fish refuses food increases, so does the danger of malnutrition and further depredation of the immune response. Perseverance and diligence is the key here - this is one of those times when the lazy aquarist is in danger of experiencing a very unpleasant loss, both financially and otherwise.

Simply put, you must offer a large variety of foods, multiple times a day, with perhaps multiple methods of presentation. While brine shrimp are far from a nutritionally suitable staple, they are often useful in jump-starting the feeding response in these fish. All of the foods mentioned above should be offered at this time, and macro-algae should always be available, and can be submersed and secured with a clip. Nori is a good option here. Once feeding commences on a given food item, you're in business! Well, at the very least you're on the way! Other foods should be offered at the same time in rotation along with whatever the accepted food is -often brine shrimp. Slowly but inevitably the list of accepted foods will grow, and you now have the ability to ensure the nutritional health of your angelfish. That wasn't so hard, was it?

Are they reef compatible?

Ahh, the eternal question! For the most part, the safe answer is "no" with regard to most species. As with most things in life however, nothing is all the time. Certain species are sometimes workable with most or some sessile invertebrates, at least for a time if not permanently. The key is acquiring the fish while young so that you can condition it to captive food offerings, and hopefully mitigate its natural grazing habits. The shortage of aquarists who've kept angels of various species in reefs for a period of 5 or 10 years is notable however, so regardless of what you do, you'll be firmly ensconced in the experimental crowd. Indeed, many of the opinions out there with regard to keeping large angels in reefs are the result of a lack of empirical data on the subject.

Even among those few species that are sometimes an option, there are individuals among them who will prove me wrong! Again, nothing is all the time, and behavior is highly variable within the group -keep that in mind as you read the rest of this section. You may attempt a species that some aquarists have had good luck with, only to find that it attacks every invertebrate in your tank! Also, some species of inverts are almost always picked on to some extent by even "reef safe" angels, including some soft corals, (especially open brain types and zooathids) some large polyped stoney corals, and tridacnid clam mantles. By far the safest type of reef to attempt an angel in is an SPS (small polyped stony coral) reef. These corals are not generally on the menu for Pomacanthids, although *anything* is fair game for an exploratory nip now and then. This brings me to my next point, which is that the aquarist must discern between a random exploratory nip, (which is very common, and normally harmless to most inverts), and more determined efforts to make coral or clam a meal. Most recently I myself had an Emperor Angel in an SPS dominated reef that also housed 3 tridacnid clams. The imperator would give the mantel on one tridacnid clam or another a good tag every few days. This wasn't enough to damage the clams or keep them closed as is often the case with angels that have decided the clam would make a proper meal. This fish did however decimate my zooanthid population, but left all other invertebrates in the tank alone. This fish did fine for over a year until the tank had to be taken down due to a move.

If in fact your angel behaves like a model citizen in your reef, this does not mean that someday , for no apparent reason, he won't decide to make a meal of one of your favorite invertebrates.

Species that can be attempted in the reef in probable order of safety include, but may not be limited to *P. diacanthus P. imperator*, *P. navarchus*, *P. maculosus* and *P. annularis*. Also, P. *asfur* can usually be maintained with SPS corals (Michael 1999), and angels of the genus *Chaetodontoplus can also be attempted, again with the caveat that some LPS and soft corals will be in danger (Schiemer, 2003).* Indeed, more often than not you'll be faced sooner or later with making the decision of whether you'd rather sacrifice certain corals, or your angelfish. Depending on the sessile invertebrates present, you'll almost certainly lose a few to your angel. Zooanthids and open brain corals seem to be among the most inviting to these fish. The good news is that small-polyped stony corals (SPS corals) are almost always ignored by the above-mentioned species.

The various species of the genus Holocanthus must absolutely be avoided - this is not the genus to attempt if you're bitten buy a bug to try something different! While I have not included angels of the genus Genicanthus in this article, they are most appropriate for larger reefs.

What can I keep with my angel?

This question is dependent on a lot of factors, including tank size and the species of angel. In general, aspiring to keep an "angel tank" is a bad idea -keeping more than one individual, regardless of species, is usually a recipe for disaster. Pomacanthids are initially delicate, yet growing into territorial, often quite pugnacious fish with capacious space demands. The average aquarist is well advised to keep one per tank. Remember the immense size of their territory in the wild! This author has kept 5 species together at once in a 200 gallon, but these were mostly juveniles, and the setup was not permanent. Certain species can sometimes be paired, but this is not an avenue for the average aquarist to pursue. However (nothing is all the time remember!) in a very large tank, say 250 gallons plus, 3 or so species can coexist if introduced properly as juveniles, if they are if disparate size and color, and allowed to grow up together. Even with 250-gallons, a larger tank will likely be necessary at some point. If attempting to mix angels, certain species should nevertheless be avoided at all cost due to their aggressive nature; among these are *H. ciliaris*, *H. passer*, *P. paru*

As far as other species are concerned, there are hundreds to choose from. Overly bellicose species such as Clown Triggers should be avoided, and while growing up they should be the dominant fish in the tank. Remember that while angels can be aggressive,

they can also succumb to stress rather quickly if they themselves are the targets of bullying.

Which species do I get?

Good question! There are a lot of variables to consider, including just about everything mentioned above, both in this article and Part 1. How large is your tank? Will you be in a position to upgrade in a few years? Are you looking to keep your angel in a reef? How experienced are you? Do you go on long vacations and leave your tank in less than experienced hands? These are things you want to consider before choosing a species, as not all of them will be appropriate for your circumstance, indeed none of them may be. So be honest with yourself before bringing one of these beauties home.

Pomacanthus imperator

Large, garish and, intelligent the Emperor Angel fish reaches 15" plus in the wild. They begin life garbed in juvenile colors that are nothing short of stunning. A dark blue background, with white circles and crescents (see photo in part I of this article) it's always been a heartbreak to me that they change at all. While their brilliant yellow, blue and black adult coloration is the height of brilliance, almost too extraordinary to be real - the juvenile stage is by far the height of beauty as far as this aquarist is concerned.

If net caught and treated well during it's trip to your local store, and then quarantined and acclimated properly, they are fairly hardy fish in captivity. Specimens from the Indian Ocean, Red Sea or Australia are the most suitable due to cyanide use in other regions discussed in part I. If kept properly, growth in this species can be quite rapid, (although any individual attaining a size close to that of the maximum adult size in the wild is rare) and a full color change can be witnessed within 3 years. If kept in quarters that are too small, and/or the diet is less than adequate, the color change can be incomplete, or else rather dull and disappointing.

One of the more eclectic eaters in the wild, *P. imperator* will accept, and should be fed a wide variety of foods, including spirulina algae, high quality angel formulations containing sponge matter, pygmy angel formulations (good for all large angels) as well as any seafood at the local grocer.

Plan ahead when adding to a reef tank, as it will eat some soft corals, and some individuals will pick at clam mantles. Adding this fish to a reef when it's between 2 and 3 inches, and feeding it well will help mitigate potential problems in this area. The species will usually leave SPS corals alone. Needs at least a 250 gallon tank for long-term well being.

Pomacanthus navarchus

Often called the Majestic Angel, this species is truly deserving of the name. Its delicate, jaw-dropping beauty often leads to an impulse purchase by uninformed keepers. Not one of the more appropriate species for captivity, this is one of the most delicate Pomacanthids, and should only be attempted by veteran aquarists who have experience keeping other angel species. They are extraordinarily shy when first introduced, which exacerbates a prolonged period of acclimation. Feeding during this period is often problematic despite the fact that their diet in the wild is diverse.

To aid their acclimatization to captivity, they should always be the first fish added to the tank (aside from a few dither fish mentioned in part 1). Not for the lazy keeper, or one who considers quarantine tanks a non-essential item! All warnings applying quarantine, acclimation and introduction in the previous installment of this article should be heeded in full with this species. Rarely growing larger than 8" in captivity, they can be kept in slightly smaller quarters as long tankmates are chosen wisely.Once acclimated, and if kept in a spacious tank of at least 180 gallons, this fish can be long-lived in captivity.

Pomacanthus navarchus

POMACANTHUS MACULOSUS

The Map Angel - now here is a species that is most appropriate for captivity, with a few caveats thrown in for good measure of course. Availability of this species is spotty at best, but captive juveniles can be found online from time to time. These fish are very hardy, (I would rank only *H. passer* and *H.clarionensis* slightly higher here) but they still need a modicum of care and patience to adapt in good time to their new home. Quarantine procedures should of course be observed as always, and a varied diet should be offered which includes sponge matter.

With a maximum size of 11 inches, this fish needs at least a 200-gallon tank to thrive and live a proper lifespan in captivity. Of course, larger is always better!

POMACANTHUS PARU

The French Angelfish is big, boisterous, very hardy, and one of the fastest, if not THE fastest growing angelfish in captivity. Growing from a small, fluttering, black and yellow juvenile to an active, somewhat more subdued adult. Feeding heavily on sponges in the wild, they adapt readily to a wide variety of captive fare - variety being the operative word as ever. Make sure to offer sponge matter in their diet, and as ever frequent feedings of a variety of quality foods is key. The tiny quarter sized individuals that are sometimes available do poorly, as do larger wild-caught individuals. Specimens in the 2" to 4" range are usually hardy, and accept a wide range of foods. This species is suitable only for very large tanks in the 250-gallon plus range, and is one of the rare species that should be added last to a tank.

HOLACANTHUS PASSER

Of the angelfish species that are commonly available to the hobbyist, the Passer or King Angelfish is without doubt the hardiest angel one can keep in an aquarium. It's close sibling, *H. clarionensis*, the Clarion Angel may be it's equal in this regard, but they are not available to aquarists on this side of the ocean for less than the equivalent of a steep mortgage payment! How hardy is the Passer Angelfish? Well they are one of the few species that this author can call hardy without adding the "for an angelfish" qualifier in front of it. Once acclimated, which doesn't take long, you'd almost have to hang it on a clothesline to kill it! They are not particularly fast growers, and can be kept in a 135 gallon tank for some time before larger quarters are needed - at least 250 gallons given their large sizes and VERY aggressive nature. Indeed, as with the Queen Angel, keeping other fish with H. passer is often a problem, and unlike some angels, it should be the last fish added to any tank.

Pomacanthus maculosus

The hardiness of this species should not be taken as license to forgo great care while acclimating it to captivity. Juveniles of at least 2" are the best prospect, but be warned that full transition to adult coloration can take upwards of 3 years or longer.

Pomacanthus paru

Holacanthus passer, juvenile.

Holocanthus ciliaris

The ever-popular Queen Angel. While my own observations indicate that they are not *quite* as bulletproof as the passer or clarion angels of the same genus, other authors rank them right up there. At the very least, the Queen is not far off the mark as long as care is taken with the initial purchase and care once it arrives home. Individuals smaller than 2", and larger than 5 or 6" should be avoided (good advise for the family as a whole) since feeding and acclimation become serious issues outside of this size range. This is a large species, and every bit as aggressive as the passer angel, something not to be taken lightly with a fish that reaches 18" in length!

Adults feed primarily on sponges, but if acquired when young, they can be acclimated to accept the offerings discussed above. With any species, variety and quality of food offerings is key, and this is never truer than with this species. Laziness on the part of the keeper that manifests in feeding a single, convenient food item will result in declining health and eventual disease and death for this and most species.

Pygoplites diacanthus

The Regal Angelfish, and deserving of this name it is! Unfortunately it's also one of the most problematic species with regard to acclimation, disease resistance and feeding. With a highly specialized diet of tunicates and sponges, duplicating this exclusive diet is impossible, and acclimating this fish to other fare is often impossible. Only for the experienced angel keeper, this species for the most part should be left in the ocean. On the upside, it's smaller size means that it can live long term in smaller quarters than most of it's other Pomacanthid congeners, however I wouldn't be quite as liberal in this area as some authors. Given the clear and obvious need to mitigate stress with this species even more than usual, 135 gallons is probably a reasonable minimum tank size for long term keeping of this species, again refer to part one for my reasoning in this regard. A good article on this species written by the late Gregory Schimer can be found at http://www.advancedaquarist.com/issues/aug2002/Fish.htm. This should cover all you need to know regarding this species. (I would respectfully recommend a slightly larger tank than is stated in his article for reasons spelled out in Part I)

Holacanthus tricolor

The Rock Beauty is the only member of the genus Holocanthus that is almost always an exceedingly poor candidate for captive life. Another sponge eater, they usually do not adapt to captive offerings, nor to the confines of the aquarium. Another fish that is frankly best left in the ocean. While on rare occasions an individual will do well for a time, this author has never seen one over a year old in captivity.

The genus *Chaetodontoplus*

Not generally as well known or popular amongst hobbyists, this genus holds a few gems that do well in captivity, and some will possibly even do well in SPS dominated reef tanks, (with no first hand experience keeping this genus in a reef, I'll leave the reader to experiment). Smaller in size than representatives from either the genus Pomacanthus or Holacanthus, they can make due with smaller quarters, in the 75 gallon range, with the exception of the Scribbled Angel (*Chaetodontoplus duboulayi*) which reaches almost 10" (8" realistically in captivity) and thus requires a tank at least in the 125 gallon range.

So there you have it! Arguably the most beautiful and elegant fish on the reef, the unparalleled interest that the Pomacanthids enjoy amongst marine hobbyists certainly reflects the validity of such a proclamation. There is nothing more spectacular than a healthy angel swimming the length of a large home aquarium. However, the wide range of size, behavior, hardiness and feeding habits, along with the attention and care required to keep them healthy in captivity dictates that their purchase not be taken lightly or made in haste. A conscientious approach to husbandry, and sense of responsibility to the animals in your charge are key ingredients with these fish, as well as all marine fish species.

With a little thought, a little planning and a desire to provide the animals in your care with research, there is no reason why you can't keep one of these beauties healthy for 15+ years in your living room!

Pygoplites diacanthus. Photo by Michael G. Moye.

ONLINE COURSES

Fish Husbandry Being Offered by Marine Aquarist Courses

By D. Wade Lehmann

Less than a month left to sign up!

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Keywords (AdvancedAquarist.com Search Enabled): D. Wade Lehmann, Fish, MACO, Marine Aquarist Courses Online
Link to original article: http://www.advancedaquarist.com/2008/3/maco

Marine Aquarist Courses Online (MACO), http://www.aquaristcourses.org/, is offering a course dealing with Fish Husbandry. The course is set to begin on April 7th. Registration is currently open and will close in early April. Join us now!

Fish Husbandry

This class will introduce you into the world of marine fish husbandry, from basic biology and taxonomy, to principles and procedures used to insure that these animals live out long and healthy lives under your care. You'll learn how to select the proper equipment, and be guided on how to set up your system in a way that suits the fish that you've chosen and the environment that you would like to emulate. Most importantly, you'll learn to avoid all the mistakes that are so easily made when learning to keep these amazing animals. The class will cover the tendencies and idiosyncrasies of various families of marine fish, how they interact with each other, and how to keep them together without experiencing the problems that plague so many aquarists. You'll learn how to manage and avoid diseases that commonly infect and often kill so many captive marine fish. You'll learn what you must do, and as importantly, what you must not do in order to excel as a marine fish keeper.

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4. **Basic Biology**: Basic Anatomy Do fish sleep? Hermaphroditism.
5. **Habitats**: Where do our fish come from? Does it matter? What is a microhabitat? What is a biotope?
6. **Tank Selection & Setup**: How big? Glass or Acrylic? Plywood? To skim or not to skim? What kind of filter? Do I need live rock? Lighting.
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8. **Stocking order & Compatibility**: What do I introduce into my tank first, and why? Can I keep fish of the same species together? Can I keep fish X with fish Y? Aggression Management/Aggressive tanks.
9. **Disease management**: Prevention and treatment of common fish diseases. Nutrition.
10. **Family Specific Discussions**: Angelfish Triggerfish Groupers Wrasses, etc
11. **Species Specific Discussions**: Open discussion on suitable species and compatibility What are the most desirable species for a reef?
12. **Fishes to avoid**: Fishes that shouldn't be purchased, and maybe shouldn't even be available!
13. **Invert Compatibility**: Can I keep this fish in my reef/this invert with my fish? Angels in the reef
14. **Nanos:** What is a nano? What makes it different? What fish can I keep in my nano? Are nanos harder to keep?

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MACO operates as a strictly online course. You are provided with access to the website that contains all of the material for your course. Each course has a private forum for its members providing direct access to your instructor for questions and discussions. There is a chat session each week to cover new material and ask questions. Each course is different, depending on the instructor and the material to be covered. This six week course is only $95 for lifetime access to the material. More specific details are available for the course on the website.

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ONLINE NEWS

Reefs in the News

From Online News Sources

Media coverage of the state of our world's reefs, interesting information, and other marine-related news.

Published March 2008, Advanced Aquarist's Online Magazine.

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Link to original article: http://www.advancedaquarist.com/marinenews

Count indicates humpback whales are heading back north (The Garden Island)

National Marine Sanctuary in the News
March 31, 2008 11:14 AM

AHUKINI â€" Cory Napoleon and Chelsea Kano were ready.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/%22National+Marine+Sanctuary%22/SIG=1217015as/*http%3A//www.kauaiworld.com/articles/2008/03/31/news/news05.txt

NOAA Studies Pollutants in Ice-Free Region of Arctic

NOAA News Releases
March 28, 2008 01:52 PM

A field study now under way is looking at the pollutants within the Arctic atmosphere â€" called â€œArctic Hazeâ€ â€" including their sources, concentrations, and climate impact, in an ice-free region.

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Source:
http://www.noaanews.noaa.gov/stories2008/20080328_arctichaze.html

Revere High teacher helping students explore marine life (West Side Leader)

Yahoo! Coral Reefs News
March 27, 2008 12:42 PM

BATH/RICHFIELD â€" Revere High School biology students took a week-long field trip to the John Pennekamp Coral Reef State Park and Key Largo National Marine Sanctuary in Florida last summer, according to their biology teacher and chaperone, Phil Mogus.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11vpf8if3/*http%3A//www.akron.com/akron-ohio-education-news.asp?aID=1985

The Great Barrier reef and beyond (International Herald Tribune)

Yahoo! Coral Reefs News
March 27, 2008 02:59 AM

From sharks to rain forests to ginger mojitos, there's something for all tastes on the Great Barrier Reef in Australia.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=124v94ist/*http%3A//www.iht.com/articles/2008/03/27/travel/26greatbarrier.php

Don't sacrifice coral reefs (The New Straits Times)

Yahoo! Coral Reefs News
March 27, 2008 02:33 AM

WITH reference to your report (NST, March 23) on the proposed coal power plant at Darvel Bay, Sabah, we agree with the suggestion by Worldwide Fund for Nature (WWF) Malaysia that there is a need to reconsider the project owing to the sensitive nature of the surrounding ecosystem.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=12mua1rkp/*http%3A//www.nst.com.my/Current_News/NST/Thursday/Letters/2196063/Article/index_html

Huge waves batter Barbados, damage coral reefs (People's Daily)

Yahoo! Coral Reefs News
March 27, 2008 12:28 AM

The beaches of Barbados are strewn with broken coral in what might be a sign of damage to reefs after unusually large waves generated by an Atlantic storm battered the region, a scientist said Sunday. The amount of debris on the isla ...

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http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11v56dgrl/*http%3A//english.people.com.cn/90001/90781/90879/6381411.html

Study: Coral reefs like 'junk food' (Moldova.org)

Yahoo! Coral Reefs News
March 26, 2008 07:40 PM

Australian scientists have discovered coral reefs have an addiction to junk food and order symbiotic algae to produce it.James Cook University researchers said the symbiosis between coral, a primitive animal, and zooxanthellae -- tiny one-celled plants -- has not only built the largest living organism on the planet, the Great Barrier Reef, but also underpins the economies of many tropical ...

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11bpbmki8/*http%3A//it.moldova.org/stiri/eng/106914/

NOAA to Study Ice Seals for Possible Listing Under Endangered Species Act

NOAA News Releases
March 26, 2008 04:32 PM

NOAAâ€™s Fisheries Service has accepted a petition from a California environmental group seeking protection under the Endangered Species Act for an ice seal called the â€œribbon sealâ€ that inhabits Alaskaâ€™s Bering Sea.

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Source:
http://www.noaanews.noaa.gov/stories2008/20080326_ribbonseal.html

Cuba may drill oil off S. Florida (Orlando Sentinel)

National Marine Sanctuary in the News
March 26, 2008 01:37 PM

The island is courting oil investors to slash its dependence on foreign fuels. Imagine oil rigs drilling in deep waters just 45 miles off the coast of South Florida. Refineries process the oil in Cuba and sell it across the Caribbean and beyond. Canadian and Mexican companies supply billions of dollars in equipment and services.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/%22National+Marine+Sanctuary%22/SIG=12q6puv2h/*http%3A//www.orlandosentinel.com/business/orl-cubaoil2608mar26,0,2511032.story?track=rss

Snorkelers and divers flock to reef off Key Largo (Miami Herald)

Yahoo! Coral Reefs News
March 26, 2008 07:14 AM

A Hollywood boat, a gangster movie and a mangrove swamp are three of the biggest on-land attractions on 33-mile-long Key Largo. The 30-foot-long boat is from the 1951 movie The African Queen with Humphrey Bogart and Katharine Hepburn. It is suspended in the air on a dock off the Overseas Highway (U.S. 1).

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11kbta6uj/*http%3A//www.miamiherald.com/986/story/468280.html

Coral Project Grows On Students (The Tampa Tribune)

Yahoo! Coral Reefs News
March 26, 2008 04:24 AM

After Sandra Varn returned from a vacation in the Florida Keys last fall, she told her fourth-graders at Cypress Creek Elementary School about the beautiful coral reefs she discovered there.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=12rhoes3r/*http%3A//southshore2.tbo.com/content/2008/mar/26/ss-coral-project-grows-on-students/?news

News Navy sonar testing: harming whales? (Haleakala Times)

National Marine Sanctuary in the News
March 25, 2008 08:22 PM

â€œThe effective use of sonar is a perishable skill that must be practiced frequently.â€ â€" U.S. Navy website â€œThe Navy is not above the law. Protecting the country includes following its laws, not skirting them.â€

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/%22National+Marine+Sanctuary%22/SIG=11leqf7ev/*http%3A//www.haleakalatimes.com/News/story2919.aspx

Symbiotic relationship between corals and algae faces threat from climate change (New Kerala)

Yahoo! Coral Reefs News
March 25, 2008 03:30 PM

Canberra, March 25 : One of nature's most fascinating symbiotic arrangement between corals and algae, which led to the formation of the Great Barrier Reef in Australia, is facing grave threats from climate change.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11t06nsha/*http%3A//www.newkerala.com/one.php?action=fullnews&id=39554

Fish key to reef climate survival (Fishupdate.com)

Yahoo! Coral Reefs News
March 25, 2008 11:50 AM

A HEALTHY fish population could be the key to ensuring coral reefs survive the impacts of climate change, pollution, overfishing and other threats. According to a BBC news report, Australian scientists found that some fish act as "lawnmowers", keeping coral free of kelp and unwanted algae.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=1319ctet5/*http%3A//www.fishupdate.com/news/fullstory.php/aid/10422/Fish_key_to_reef_climate_survival.html

Delicate Partnership Between Coral And Algae Threatened By Global Warming

ScienceDaily: Coral Reef News
March 25, 2008 09:00 AM

Over two hundred million humans depend for their subsistence on the fact that coral has an addiction to "junk food" -- and orders its partners, the symbiotic algae, to make it. This curious arrangement is one of nature's most delicate and complex partnerships -- a collaboration now facing grave threats from climate change.

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Source:
http://www.sciencedaily.com/releases/2008/03/080324091101.htm

Climate change 'can be measured daily' (Daily Telegraph)

Yahoo! Coral Reefs News
March 25, 2008 03:37 AM

AN Australian researcher says climate change could be measured on a daily basis, not just in the long term, by monitoring changes in coral.

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Source:
http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=130ubgtqh/*http%3A//www.news.com.au/dailytelegraph/story/0,22049,23429099-5001028,00.html?from=public_rss

Giant waves break up Caribbean coral (The San Luis Obispo Tribune)

Yahoo! Coral Reefs News
March 24, 2008 09:47 PM

Unusually large waves churned by an Atlantic storm system have littered the beaches of Barbados with broken coral in what could be a sign of damage to reefs across the region, a scientist said Sunday. The amount of rubble on the island's west coast suggests the coral took a heavy pounding, said Leo Brewster, director of Barbados' Coastal Zone Management Unit, who was organizing dives later this ...

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http://us.rd.yahoo.com/dailynews/rss/search/coral+reef/SIG=11piknj2p/*http%3A//www.sanluisobispo.com/health/story/313209.html

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MarineDepot.com is the current leader in supplying marine and reef aquarium supplies. We simply try to make as many people (including both our staff and our customers) as happy as possible. We found that we have been able to accomplish this by maintaining extremely low prices, providing friendly customer service, and simply liking what we do.

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Deltec aquarium equipment is renowned throughout the world for its high performance and superior quality. Deltec has been in the marine aquarium business for more than 20 years in Europe, and developed the pinwheel more than 19 years ago.

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An important goal of the Southern California Caulerpa Action Team is the detection of undiscovered infestations of C. taxifolia or other invasive species of Caulerpa, and the prevention of their spread.

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"www.reefs.org - If you had to pick a "one-stop shop" for everything online for reefs, this would be it. If you can't find it here, you can't find it." – Richard Sexton, Tropical Fish Hobbyist, November, 2002

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